Version 1.2

IC-MinEval

Software for the Financial Evaluation
of Mineral Deposits

IC-FinEval Ltd

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Contents

1. Introduction

Valuation of mineral projects can be based on the following methods:

Discounted Cash Flow.
Earnings Multiples.
Market Capitalisation.

Of these, the Discounted Cash Flow (DCF) method has the advantage that a model can be constructed which reflects the primary technical features of the project while minimising the inherent subjective element of the valuation process. This does require a level of knowledge about the operation which may not be available outside the Company, but it is still possible to develop a model based on comparative scenarios which can provide the basis for a preliminary valuation. This approach was followed as part of a programme of research at Imperial College arising from comments received from delegates on related short courses on mineral deposit evaluation and resulted in the development of **IC-MinEval**, a new Excel spreadsheet-based DCF modelling tool. **IC-MinEval** offers an expert approach to preliminary level valuations of mineral projects for the purpose of evaluating for economic feasibility, potential project financing or merger and acquisition deals.

2. Description of IC-MinEval

***IC-MinEval** automates all the stages required to produce an Excel-based DCF model of a mining project through a series of clearly defined menu-driven forms.* These prompt the user to enter all the necessary technical and financial variables. As independent technical variables such as grade, tonnage and resource volume are entered, corresponding values for dependent variables such as metal tonnage and resource tonnage are indicated in the forms. Through the use of a dynamic Help system, all the variables and their relationships are explained so the user knows what information is required. *If information is not available on the mining rate or costs, typical values can be suggested using empirical formulae*.

Once the key technical and financial data has been entered, it is checked and a comprehensive series of Visual Basic routines ensures that a set of Excel worksheets are generated to form a customised DCF model. As these variables are added to or altered, the Visual Basic routines ensure that all the cells and columns in the worksheets are automatically revised. Consequential changes to the model, such as mine life, are also automatically implemented. ***IC-MinEval** therefore provides a quick and flexible way of producing a customised DCF model of a mining project while minimising the potential for human error inherent in conventional Excel modelling. Subsequent changes to input variables are incorporated and the model automatically updated*.

IC-MinEval allows the user to consider a range of financial parameters such as environmental costs, taxation and the proportion of debt and equity. Variable production rates during the initial period of the project can be accommodated as can the rate of capital expenditure. If the user wishes to include debt financing in the model, **IC-MinEval** can automate the financial engineering required to define the optimum funding structure and drawdown schedule. **IC-MinEval** also produces a Balance Sheet and Profit and Loss account, all linked to the DCF model (including the tax scenarios). Output modules include the base case discount cash flows as well as key financial ratios and performance indicators such as NPV, IRR, payback, maximum cash exposure and debt service ratios. Sensitivity analysis can be undertaken on key variables using spider diagrams. ***IC-MinEval** therefore produces a fully integrated set of output sheets that provide a comprehensive financial model of the project.*

IC-MinEval is not designed to replace the complex models generated as part of a full feasibility study of a specific project, nor can it be compared with a stand-alone software package. However, because it is based on an Excel spreadsheet it does provide flexibility and power through the ability to modify the worksheets generated by the menu-driven forms. These can be customised to incorporate project specific information such as tax concessions and grants. *When the modified worksheet is inserted into the spreadsheet, **IC-MinEval** will link and update the DCF model*. This flexibility also extends to the presentation of the results. Because the model is produced as an Excel spreadsheet, it is very easy to incorporate the charts and tables generated by **IC-MinEval** directly into reports or presentations. It also allows the user to undertake preliminary on-site screening of projects during assessment exercises.

3. System/ Software Requirements

Pentium 100MHZ or higher with 32MB RAM
Windows 95/98 or NT
Microsoft Excel 97 or later (English Version)

In order to use **IC-MinEval** you must have Excel and have installed VBA (Visual Basic for Applications) when Excel was installed.
If you did not install the full version, you will need to install it.

1. Quit Excel.
2. Put the Microsoft Office or Microsoft Excel CD into the CD ROM drive.
3. If a Microsoft Office or Excel window (as appropriate) does not appear
   3a. Either select the CD-ROM drive in Explorer or double click on the "*My Computer*" icon and select the CD-ROM drive.
4. Click on the "*Install Microsoft Excel*" icon.
5. Select the "*Add/ Remove*" components button.
6. Select the "*Data Access*" checkbox.
7. Click on the "*Continue*" button.
8. When the installation has finished, restart the computer when prompted.
9. When the computer has restarted you will be able to use **IC-MinEval**.

4. Installing IC-MinEval

The simplest way to install **IC-MinEval** on your hard drive is to use the Windows Explorer.

1. Place the **IC-MinEval** floppy disk in the floppy drive.
2. Open Windows Explorer.
3. Double click on the floppy drive icon.
4. From the Windows Explorer Edit menu select *Setup.exe*.
   This will start the installation program and you will be prompted for the necessary information, as it is required.
5. You should put the **IC-MinEval** installation disk in a safe place in case you need to re-install the program in the future.

During the installation procedure you will be asked to enter your name, company and serial number. The serial number is required to run the installation procedure and **IC-MinEval**. It can be found inside the back cover of this manual and if you wish to contact us (See section *6. Contacting Us*), you should always include you serial number.

You may wish to create a desktop shortcut to run **IC-MinEval**. If so:

1. Open Windows Explorer if it is not open already.
2. Double click on the **IC-MinEval** folder on your hard drive.
3. Locate the file **IC-MinEval**.xls
4. From the Windows Explorer Edit menu select *Copy*, or press *Ctrl + C* simultaneously.
5. Close or minimise Windows Explorer.
6. Place your mouse in an empty area of the Desktop window and press the right mouse button.
7. From the resulting menu select *Paste.Shortcut*.

This will now create an icon in your desktop that you can select to run **IC-MinEval**.

If you wish to change the name or icon of the shortcut:

1. Select the **IC-MinEval** shortcut icon (don’t double click as this will start **IC-MinEval**).
2. Press the right mouse button.
3. From the resulting menu select *Properties*.

This will display a list of options you can choose to change the label or icon of the shortcut. For more information on this press F1 or consult your Windows user manual. There is an icon (IC-MinEval.ico) in the **IC-MinEval** installation directory you may wish to use.

5. Troubleshooting

If you have a problem with the operation of **IC-MinEval**, please check the following before contacting us:

1. Did you install **IC-MinEval** using the installation disks? You must install IC-MinEval using the installation disks in order for all the necessary files to be installed correctly.

2. Do you have a valid serial number? Each copy of IC-MinEval requires the correct serial number to be entered during installation. If you are sure you have the correct serial number, but you still can not install **IC-MinEval** correctly please contact us via one of the methods given in the next section.

3. Is Excel fully installed, including VBA (Visual Basic for Applications)?
If not see section 3, *System Requirements*.

4. Is the correct version of Excel installed, **IC-MinEval** required Excel version 8.0 (Excel 97) or higher to run.
To check this select *Help* and then *System Information* in Excel.

5. Did you click on *Enable Macros* when **IC-MinEval** started? (See section *8. Running **IC-MinEval**) if* you did not, **IC-MinEval** will not work.
Close and the reopen **IC-MinEval** and click on *Enable Macros*.

6. Do you have enough memory to run Excel and **IC-MinEval?** If you do not you will get a *Not Enough Memory* message and notice problems with the display.
If this is the case you can attempt to increase the amount of virtual memory to improve the situation as follows:
   1. Under the Windows Control Panel, double click on *System*.
   2. Select the *Performance* tab
   3. Click on the *Let Windows manage my Virtual Memory settings* option
   4. Click on *Ok* and then *Ok* in the *System* dialog to finish.

If these items do not describe your problem, please contact our technical support via one of the methods described below.

6. Contacting Us

As part of our efforts to improve **IC-MinEval** we'd like to hear from you and encourage your questions, comments and suggestions regarding this version of **IC-MinEval**. If you wish to contact us please do so either by:

Email: info@IC-FinEval.com or support@IC-FinEval.com
Phone: +44 (0)207 917 9838

Or by mail at:

IC-FinEval Ltd.,
212 Piccadilly
London
W1J 9HG
England

If you do contact us please include your name, company, as well as the serial number and version number of **IC-MinEval** you are using. All this information is displayed on the opening screen when you start **IC-MinEval**.

7. Navigating Through IC-MinEval and Conventions Used in the Manual.

As **IC-MinEval** is a windows based product, the controls will be familiar to all users, especially those who have used Excel. The forms and input sheets are all controlled by mouse and/or keyboard. Selecting an input box with a mouse activates it, allowing you to change or add the information present. Alternatively, you can use the keyboard either by:

1. Pressing *TAB*. This cycles through all the available controls and you can move through all the controls until you reach the one you wish to use.

2. Hot Keys. Pressing Alt and a second key simultaneously activates hot Keys. The required hot key is usually underlined on the button label e.g. Agree. In this case to activate this button press *Alt + A*. Hot keys are written in this manual as *Alt + letter* and are usually included within brackets. Sometimes it is impossible to avoid having the same hotkeys for different controls in the same sheet, such as on the *Main Menu*. In such cases repeatedly pressing the hotkey combination will rotate through the controls.

As with most windows applications the currently active form can be dismissed by pressing *Escape* (often displayed as *Esc* on your keyboard).
Pressing *Return* or *Enter* activates the default button, usually *OK*, so care should be taken not to press *Return* when you enter values.
Pressing *F1* will display the context sensitive help where available, which will give information on the currently active screen. This can also normally be done by pressing *Alt+H*.
When you are in Excel, there will be an additional menu displayed. This is the *IC-MinEval* menu and allows you to display the main *Menu*, *Colour* code the input sheet, display additional *Help* or display information *About* **IC-MinEval**, including the serial and version numbers.

8. Running IC-MinEval

To start running **IC-MinEval** either:

1. Double click on the **IC-MinEval** icon on your desktop (see section *4. Installing IC-MinEval* for details on how to set this up).
2. Select the **IC-MinEval** icon from your start menu.
3. Double click on the **IC-MinEval**.xls file in windows explorer.
4. Whilst in Excel open the file **IC-MinEval**.xls in the installation directory.

Although this version of **IC-MinEval** does not include the required links to *@Risk* by Palisade, you should always start *@Risk* before **IC-MinEval** if you wish to use it in conjunction with **IC-MinEval** to carry out Monte Carlo simulations on the generated model.

IC-MinEval requires Visual Basic for Applications to be installed with Excel in order to function (VBA comes with Excel and if you have not installed it you will need to do so, see section 3, *System Requirements*, for details of how to do this).
When you start **IC-MinEval** you may be presented with the dialog shown in figure 8.1. If so you must select *Enable Macros* in order to fully use **IC-MinEval**.

Once **IC-MinEval** has been successfully opened, the opening screen will be displayed (Figure 8.2). This screen contains your user information as well as product information including the serial number and version number. You will require these should you wish to contact us (see section 6, *Contacting Us*, for further details). If you do not see this screen and **IC-MinEval** exits, you may have a problem with the installation and you should re-install **IC-MinEval** using the installation disks.

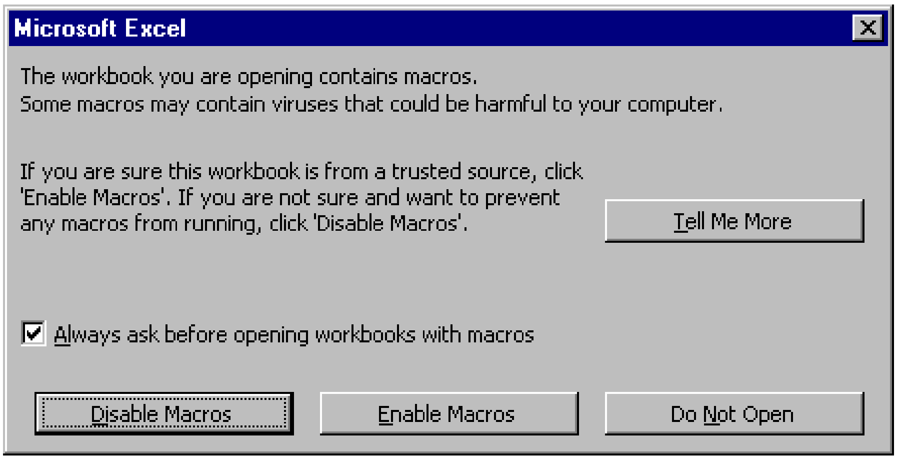

Figure 8.1: Excel dialog informing the user that the workbook they are attempting to open contains macros.

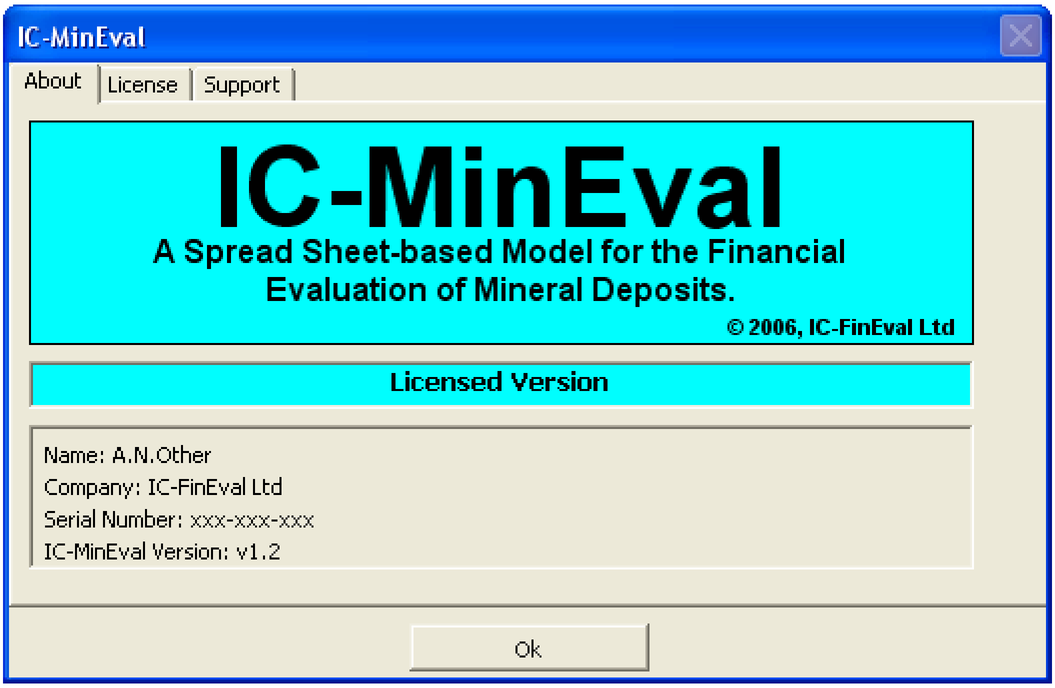

Figure 8.2: The **IC-MinEval** opening screen.

9. IC-MinEval Quick Start Tutorial - Botswana Gold Project

The following scenario of a gold project in Botswana shows how quick and easy it is to create a full DCF model using **IC-MinEval**. This tutorial should take no more than about 20 minutes, after which you will have created a full set of Excel-based output sheets for your perusal. The scenario used here covers the basics of **IC-MinEval**, but does not incorporate project finance or inflation etc. To create the model simply work through the instruction guide that follows the scenario description below. This tutorial is designed to familiarise you with the **IC-MinEval** data input forms.

Scenario

"It is proposed to establish an underground gold mine and mill, with a capacity of 1,000 tonnes of ore per day (in calculations 360 working days per year), in Botswana. The mining reserves are 3.24 million tonnes of in-situ mineralised material with an in situ grade of 10 g Au/ tonne. It is estimated that the dilution will be 9% and the mill recovery will be 90%. The capital cost is estimated to be US $55 million. There will be two pre-production years. 40% of the capital cost will be incurred in the first pre-production year and 60% of the capital cost will be incurred in the second pre-production year. The unit operating costs have been estimated to be US $40 per tonne of ore. Working capital has been assumed to be 25% of annual operating costs. The assumed gold price is US $300/troy oz (in calculations use 31.1 g/troy oz). Assume a tax rate of 35% of taxable income. Capital allowances can be claimed as straight-line depreciation over the mine production life. A royalty of 2% of gross mineral value is payable."

Starting IC-MinEval

When you start IC-MinEval you will be presented with the main menu, which allows you to set-up the model, view the output or run more complex analysis on the project once it is set-up. However, before you will need to create the initial project, so select the **General Information** button.

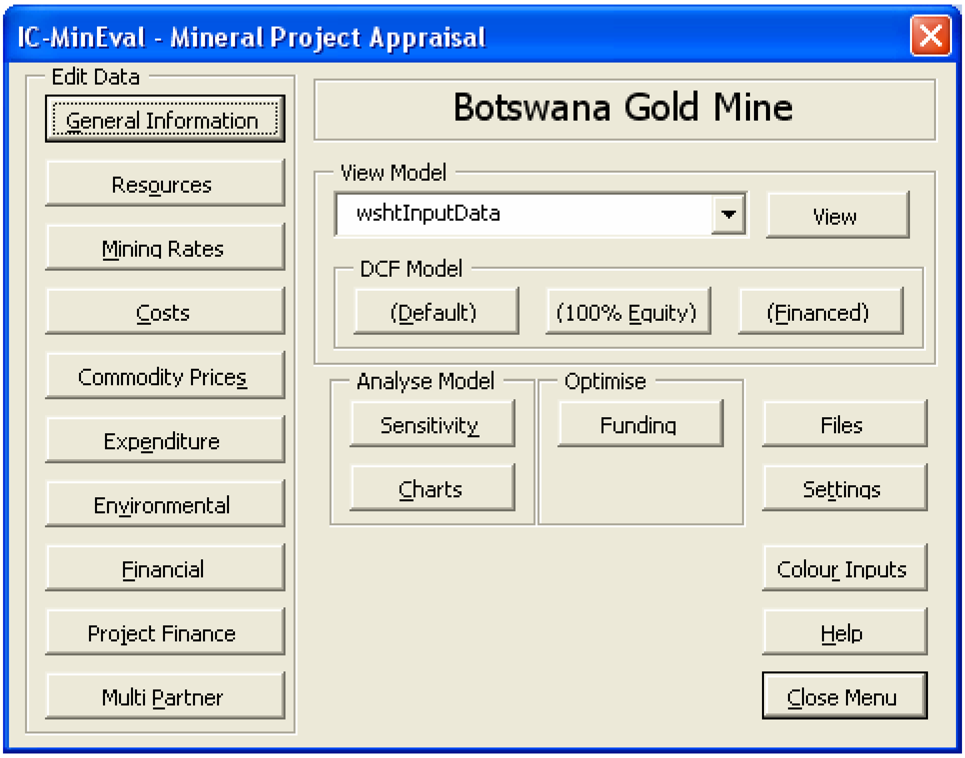

Figure 9.1: The **IC-MinEval** Main Menu.

General Information

After entering the **project name**, the project basics are entered. As this scenario is a gold project, **Au** is selected, however IC-MinEval can be used to model multi-commodity projects including Gold, Silver, Lead, Zinc, Copper, Nickel, Molybdenum, Tin, Platinum, Palladium, Rhodium, Iridium, Ruthenium, Osmium, Diamonds, Coal (Steam, Coking and Anthracite) and Industrial Minerals, either as predefined deposit types or using the custom type to define your own specific combination of commodities.

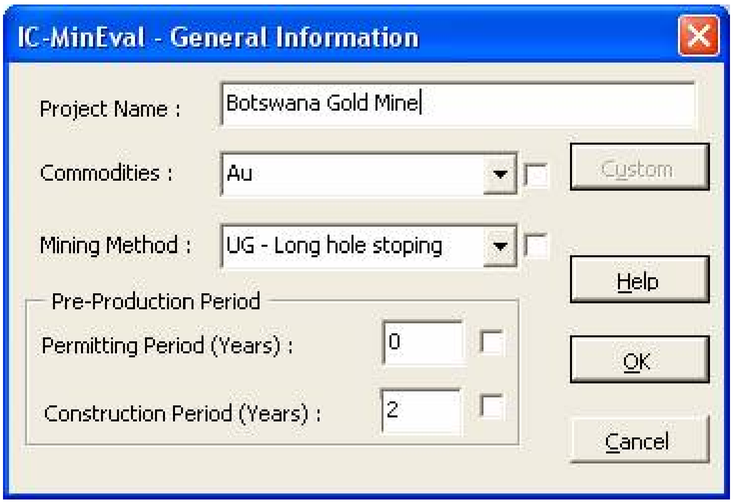

Figure 9.2: General Information Menu.

After the deposit type has been defined the mining method is selected from the available list. The differing mining methods enable different options including stripping ratio for underground and specific costs information. For this scenario the mining method **long hole stoping** is selected. The pre-production period allows both the permitting period and the construction period to be defined. This is useful if you have a period before the first expenditure and / or production starts. In this case we have **two pre-production years** during which construction takes place and so we enter **2** into the construction period.

Resources

Once the project has been defined we can set up the details of the project's resources and grades. We have been told the project has an in-situ resource of 3.24 million tonnes. The In situ resource is what is in the ground and will be more than what we are actually able to mine. Based on the geology we can calculate that, given a specific gravity of **2.6**, the total mineralised volume is **1.246 million m^3**. Alternatively, if you do not know the SG, you can enter 1 and then enter the volume as the in situ tonnage as this will not effect the calculations. As you enter values into the forms, several calculations are made and these are also displayed on the form, such as in situ tonnage, total mined etc.

We can now determine how much of the in situ ore is mined. In this case we have entered **100%** which would be unusual, as we would expect some of the material to be uneconomic to extract. Next we can enter any dilution factor, in this scenario **9%** which means that for every 9.1 tonnes of ore we extract we will also extract 0.9 tonnes of sub-economic rock. Having some dilution is normal, as it is often caused by mining conditions, but the key is to keep it to a minimum as it is also often caused by poor grade control. Upon entering these values we can immediately see that over the entire life of mine we will be extracting 0.29 Mt of sub-economic material, or a

combined total or 3.53 million tonnes. As this is an underground operation the striping ratio has been disabled.

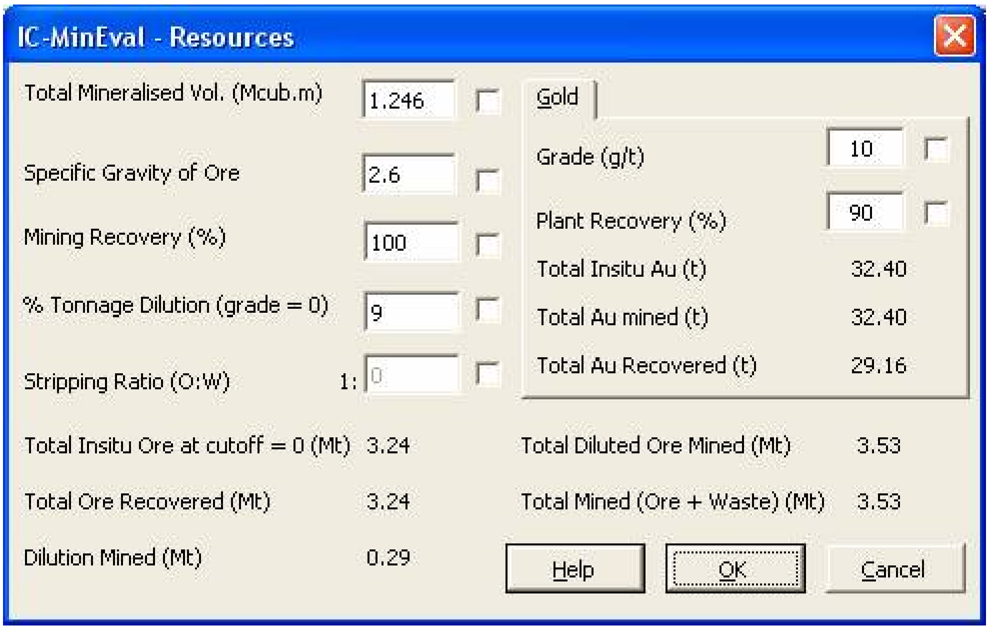

Figure 9.3: The Resources Menu.

Once the total resource has been defined we are able to define the grade and plant recovery. The in situ grade here is **10 g/t** and we have been given a plant recovery of **90%**. Based on these figures, we have 32.4 tonnes of gold in situ of which we are able to extract 29.16 tonnes. In a multi-commodity deposit extra tabs would be displayed for each commodity for entering the grade and recovery.
Once we have entered all the relevant figures we can **click on OK** and the model will be updated, setting up each commodity with the correct units (g/t, % etc).

Mining Rates
With the deposit's resources defined we can now specify how the deposit is to be mined and calculate the mine life.

The **Mining Rates** form gives us several different ways of entering the mining rates. We can either estimate it by entering the mining rate per day (this is the amount of rock and waste removed) or use a calculation-based approach to approximate the rate based on published data. We know that the mining rate will be 1000 tonnes per day so we can select the **Estimate Mining Rate option** to estimate the rate and enter **1000** in the mining rate box. We also know that the mine should operate for **360 days** per year, which when we enter into the working days/ year box automatically calculates the total mined per year.
We also have the option to ramp up the production rates over the start of the project as it may take a year or more to achieve the optimum production rates. However, we will keep the production rates at **100%** throughout the mine life, which is calculated as 9.81 years. Once we have made these changes and **select OK**, the model will automatically update and the correct number of columns will be setup throughout the model (10 for the production period and 2 for the construction period).

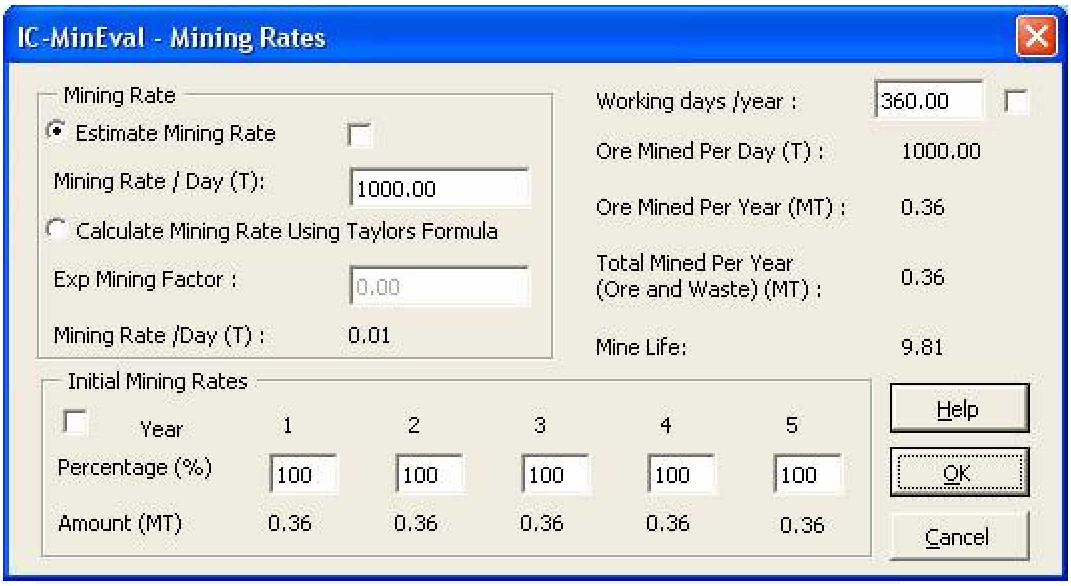

Figure 9.4: The Mining Rates Menu.

Costs

The project costs are an important part of any project and IC-MinEval is flexible enough to allow you to make your cost estimations as detailed as you require, enabling you to link into your own cost models or use the built in functionality of IC-MinEval.

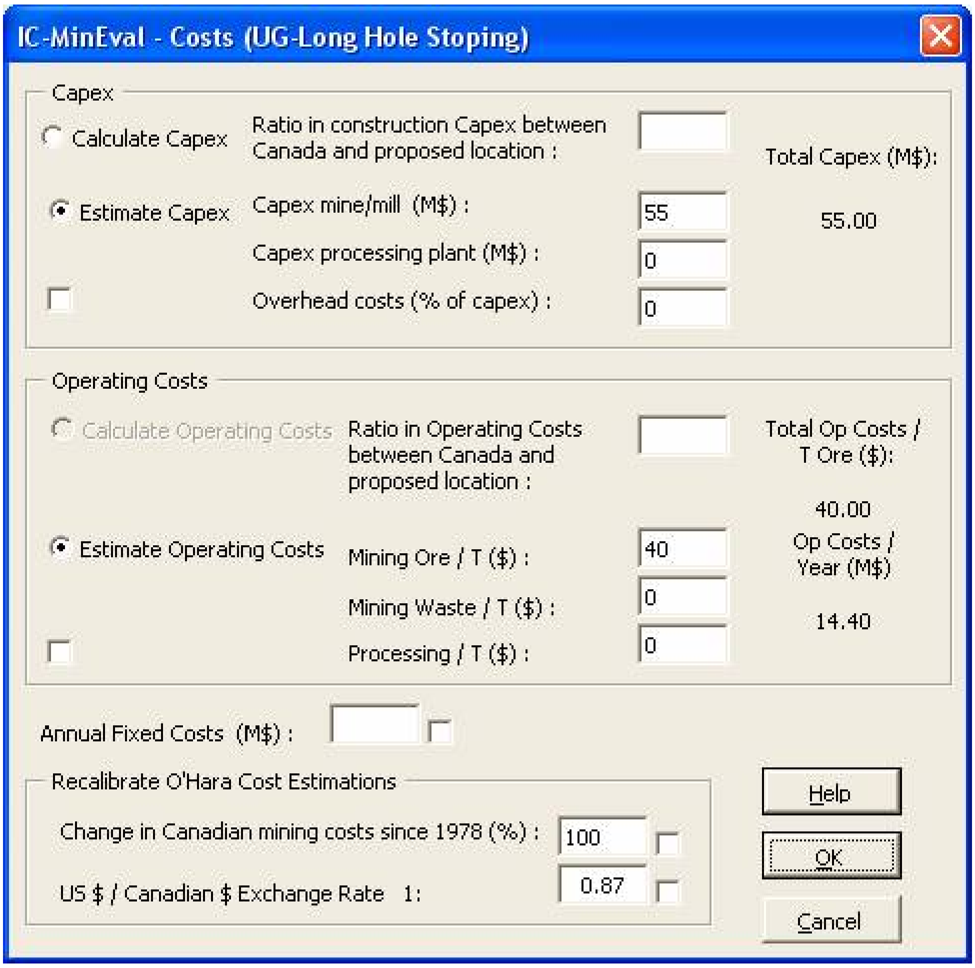

Figure 9.5: The Costs Menu.

If you have no cost figures available, IC-MinEval can calculate basic Capex costs for open pit and underground gold projects and Op Costs for Open pit gold projects.
For this scenario we have only been provided with basic costs and so we can enter the Capex of **US$ 55 million** and operating costs of **US$ 40 per tonne**. We have no fixed costs and so can leave this as **zero**. The other options on this module refer to the built in cost estimation.

Commodity Prices

The commodity prices menu allows us to set the initial gold price and specify how this will vary over the life of the project (increase with inflation, increase/decrease by fixed percentage or remain constant). The base case we are looking at here has a constant gold price of **US$ 300**, so we set the spot price as thus and **select fixed**.

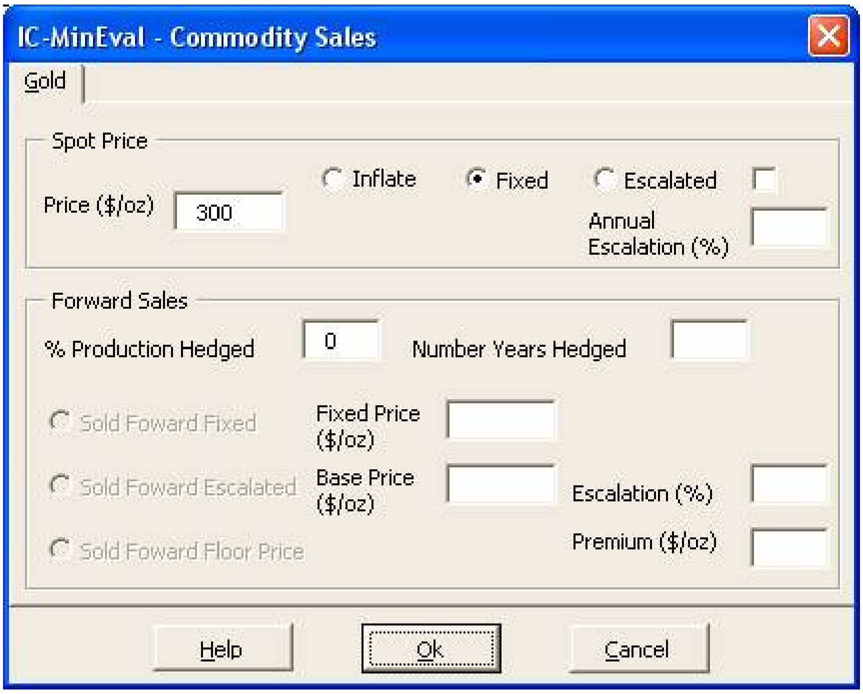

Figure 9.6: The Commodity Prices Menu.

As well as setting up the spot price, you have the option to forward sell a percentage of production for a specified number of years. Although this is not required in the base case it is something that we can look at when doing some scenario analysis.

Expenditure

As we have specified US$ 55 million as Capex, we are able to split this **40%** / **60%** over the 2 year construction period by entering these values under the Capex payment schedule. When doing this, the actual amount is calculated and displayed for you to check. In this case US$ 22 million and US$ 33 million, respectively.

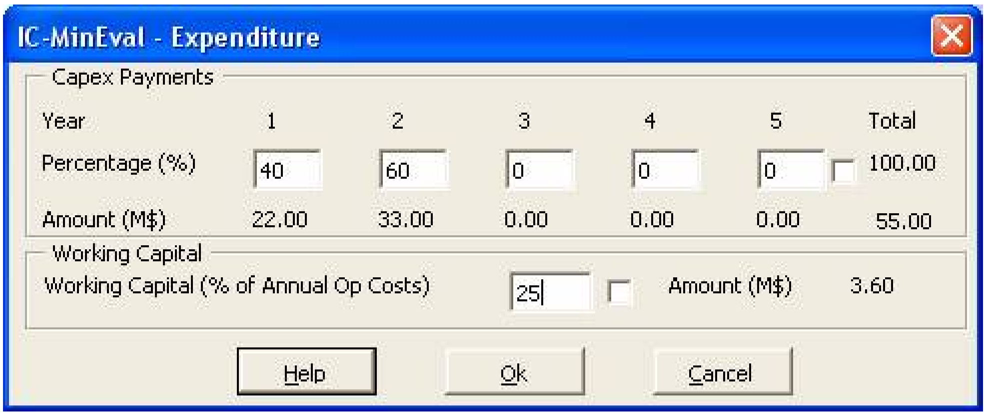

Figure 9.7: The Expenditure Menu.

Also on the expenditure form we can set the level of working capital. This is a percentage of annual operating costs, so setting the value to **25%** as specified in the project scenario is equivalent to 3 months, and works out as US$ 3.6 million.

Environmental & Closure Provision

Included in the package is the ability to model ongoing environment and closure expenditure including up front (sink fund), post (bullet) and annual costs during production and for a specified period postproduction.

The base case used here does not include any E&C provision, so these values are left at **zero**.

Figure 9.8: The Environmental and Closure Provision Menu.

Financial

After defining the deposit we can look at the financial regime in more detail, including taxation and the discount rate we will use to value the project. For this scenario we are using **straight-line depreciation**. This allows us to use the Capex to reduce the taxable income by the same amount each year of production. The royalty rate is set to **2%** and the basic tax rate to **35%**. This sets up the basic tax parameters for the project. If you have a more complex tax structure IC-MinEval allows you to design custom tax modules which you can save and import into models as required.

Figure 9.9: The Financial Menu.

The model assumes zero inflation so we can leave the annual inflation to **0%**. The cost of capital for the project is **8%**, which we set as the discount rate. IC-MinEval can be used to model the project finance and allows you to calculate the NPV using the Weighted Average Cost of Capital (WACC) including variable WACC as debt is repaid instead of using a fixed discount rate if required. However, the base case scenario assumes no debt finance and so **discount rate** is selected to calculate NPV.

Project Finance And Multi-Partner
At this stage we are only performing a basic financial analysis of the project, and so all the tabs are left at **zero** before we **click OK** to exit the project finance form. Later we can model how the project is to be funded and the effect this has on the project viability, by using this module to structure the funding and calculate the distribution to multiple partners post-funding. We can also then look at revenues for multiple participants in the project
As well as setting up the funding, IC-MinEval includes the ability to calculate the minimum level of funding required so as never to give a negative cash balance over the project life (if possible), and automatically calculates all the standard ratios required for examining the loan structure.

Results
We have now finished setting up the model in around 20 minutes. This has generated a fully linked Excel spreadsheet model, detailing how the financial model is built up from the initial inputs through the resources, the production schedule, revenues, tax to produce the DCF worksheet fully linked into the P&L and Balance sheets. A series of charts are automatically produced allowing you to visually compare the cash flows and others can be selected from the IC-MinEval main menu. The sheets are accessed by clicking **Close Menu** and selecting the desired worksheet from the tabs displayed at the bottom of the screen. The menu can be accessed again at any time by pulling down the **IC-MinEval** tab on the tool bar at the top of the screen and selecting **Show Menu**.
Once the model has been created it is very easy to vary the parameters and run “what if” scenarios using either the built in Excel or IC-MinEval functions, such as sensitivity analysis which is included in the IC-MinEval package. Together with the formal financial statements and cash flow charts produced, these facilitate a thorough analysis of the project’s economics.

10. Description of Controls, Worksheets and Output.

As you have seen from the quick-start tutorial, **IC-MinEval** consists of two main components. The first are the input screens, which are written in Visual Basic and prompt you for all the necessary technical and financial data. The second are the worksheets and graphs that contain all the data, calculations and output generated by **IC-MinEval**. The following three sections describe all of these, detailing the type of information required and the results produced.

10.1 Input Sheets

10.1.1 Main Menu

The main menu shown in Figure 10.1, controls **IC-MinEval** allowing you to edit data, view the worksheets, create charts, run a sensitivity analysis or to load and save data.

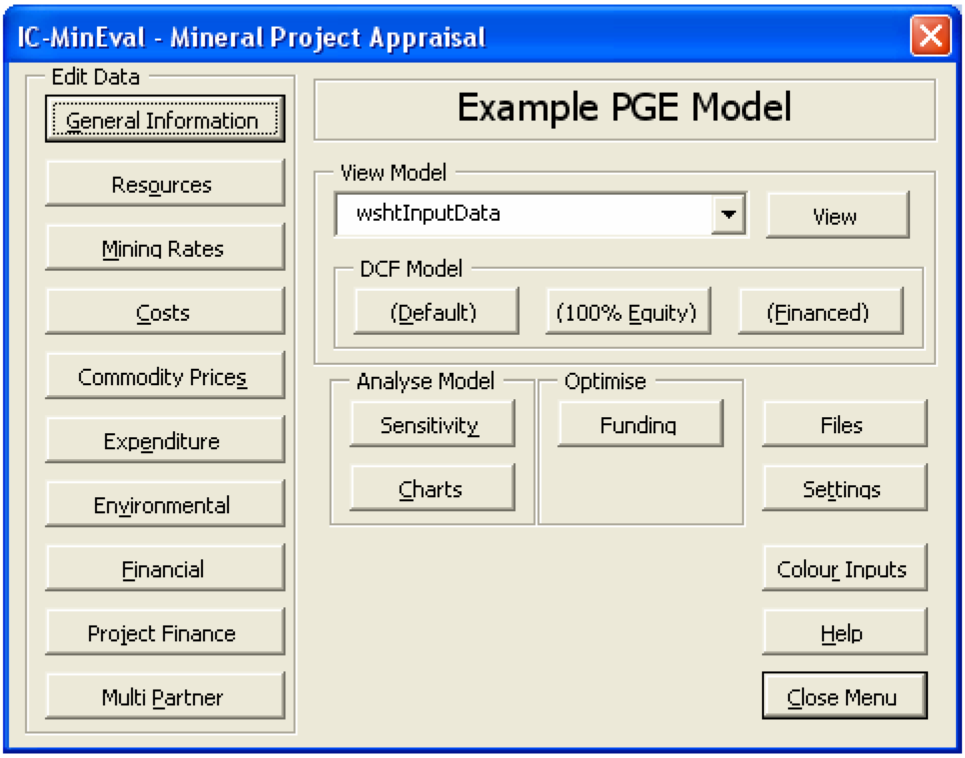

Figure 10.1: The **IC-MinEval** Main Menu.

Each of the controls in the *Main Menu* are described as follows:

Edit Data

General Information (Alt + G)

Selecting the General Information button displays the *General Information* screen (10.1.2), which allows you to change the project title, the deposit type, the mining method and the period required for permitting and construction.

Resources (Alt + O)

Displays the *Resources* screen (10.1.3), which allows you to alter the mineralised volume, ore density, mining recovery, dilution and stripping ratio of open pit operations. The *Resources* screen also allows you to set the grade and plant recovery for each metal.

Mining Rates (Alt + M)

Displays the *Mining Rates* screen (10.1.4), which allows you to change the mining rate per day, the number of workdays per year, and to set the initial mining rates over the first five years of mining.
Costs (Alt + C)
Displays the *Costs* screen (10.1.5), which allows you to set the Capex and operating costs for the project.
Commodity Prices (Alt + S)
Displays the *Metals Sales* screen (10.1.6), allowing you to set the spot and forward price of all the metals mined.
Expenditure (Alt + E)
Displays the *Expenditure* screen (10.1.7), which allows you to spread the Capex payments over the first five years and to set the percentage working capital to be employed.
Environmental (Alt + V)
Displays the *Environmental and Closure Provision* screen (10.1.8), which allows you to set-up the environmental costs prior, during and post production. It also allows you to set the time of the environmental clean up and closure period.
Financial (Alt + F)
Displays the *Financial* screen (10.1.9), which allows you to set the royalty rate, tax rate, annual inflation and the discount rate, as well as set the method for calculating depreciation.
Project Finance (Alt + J)
Displays the *Project Finance* screen (10.1.10), which allows you to set the capital structure, loan repayment schedule and interest rate.
Multi Partner (Alt + P)
Displays the *Multi Partner* screen (10.1.11), which allows you distribute the cash flows post funding to all the partners in the operation.

View Model
Select the worksheet you wish to view and select the **View** button to be taken to the relevant worksheet or chart, which are described in section 10.2.

DCF Model
Default (Alt + D)
Displays the *wshtDCF* worksheet, before and after funding.
100% Equity (Alt + E)
Displays the *wshtDCF* worksheet, assuming 100% equity.
Financed (Alt + F)
Displays the *wshtDCF* worksheet including funding, taxation and interest payments.

All three of these DCF Model options use *Custom Views*. These views must exist in the **IC-MinEval** worksheet for these functions to work. By using *Custom Views*, if you change the layout of *wshtDCF* you need to change the settings of the three views for the correct information to be displayed.

Analyse Model
Sensitivity (Alt + Y)
This button displays the *Sensitivity Analysis* form (10.3.1), which allows for the automatic generation of spider diagrams to show the sensitivity of the project to changes in the selected parameters.

Funding (Alt + G)
Allows the model to automatically calculate the required amount of *funding* at the selected level of debt and equity, subject to the constraints selected in the *Project Finance* form (10.1.10).
Charts (Alt + C)
Displays the *Charts* form (10.3.2), which allows the required cash flows or ratios to be selected and displayed in chart form.

Colour Inputs (Alt + R)
Checks the contents of *wshtInputData* worksheet and colour codes the contents depending on whether they are values, formulae or text. This makes it easier when checking the worksheet to identify which values can be changed manually.

Files (Alt + F)
Displays the *Files* screen, which allows the saving, and loading of data sets or custom tax sheets (10.3.3).

Settings (Alt + T)
Displays the *Settings* screen, which allows the user to set which worksheets are updated by **IC-MinEval** (10.3.4).

Help (Alt + H)
Displays the **IC-MinEval** *Help* file.

Close Menu (Alt + C)
Closes the main menu, so the user can examine the model in *Excel*. You should use this option if you wish to save any changes or graphs you have made.

10.1.2 General Information

This menu (figure 10.2) allows you to set up the projects basic parameters.

Project Name
Sets a title for the current project. This is a text string and can contain any combination of letters and numbers.

Commodities
Sets which commodities the project is to mine. Selecting different commodities updates all the labels and units in the worksheets.
This is a drop down menu and you can select one of the following:

Au, Cu, Ag, Pb,Zn,Ag, Cu,Mo, Cu,Au, Cu,Zn, Cu,Zn,Sn, Au,Cu,Ag, Cu,Ag, Au,Ag, Cu,Ni, Diamonds, Pt,Pd,Rh,Ir,Ru,Os, Pt,Pd,Rh,Ir,Ru,Os,Cu,Ni, Pt,Pd,Rh,Au, Pt,Pd,Rh,Ir,Ru,Au,Cu,Ni, Coal, Industrial Minerals, Mineral Sands (Rutile, Ilmenite, Garnet and Zircon), U3O8 (Uranium) and Custom

Each of these commodity groups represents a group of metals or non-metaliferous elements that commonly occur together in economic quantities in the major mineral deposit types found in nature. See *Appendix C* for details of the deposit type(s) each commodity group is associated with.
Custom is a special range of commodities that is specified by the user through the Custom Commodities form. This is accessed by selecting Custom from the commodities dropdown list and then clicking on the Custom button (10.1.2.1). The Custom function can be used to modify the commodity group if it varies from the characteristic metal association of one of the deposit types detailed in *Appendix C* and includes some commodities not included in the main list.

Mining Method
This drop down menu displays the available mining methods including open pit and a range of underground mining methods.
In this version of **IC-MinEval** the major difference between these are:

1. Selecting *Open Pit* allows you to set a stripping ratio in *Resources* (10.1.3).
2. Selecting *Open Pit* or an *Underground Method* gives different gold Capex costs, when calculated using the modified O'Hara formulae in *Costs* (10.1.4).
3. Selecting *Open Pit* allows you to use the O'Hara formula to calculate the Op-Costs of a gold project in *Costs* (10.1.4).

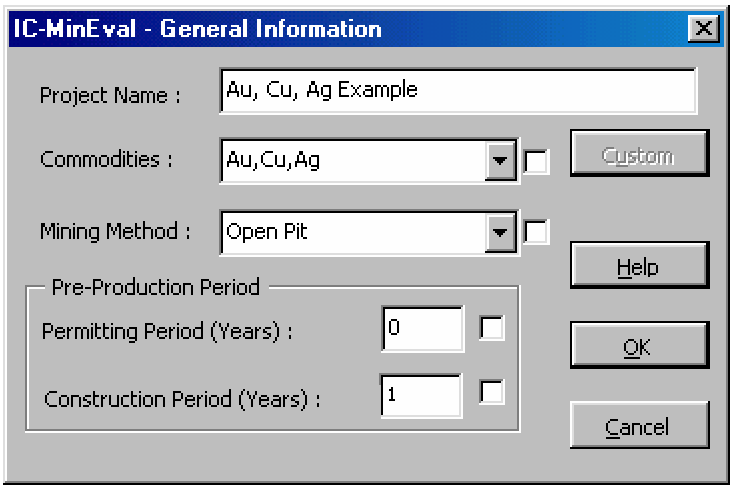

Figure 10.2: General Information.

Permitting Period
This allows you to set the time taken to obtain the necessary documentation and permitting, and the time required constructing the plant etc. These are then combined and used to determine the pre-production period, the time after the initial Capex has been spent before production (and revenue) can begin. In terms of project finance, this end of this period signifies completion when the project's cash flows become the primary source of debt repayment.

10.1.2.1 Custom Commodities

The custom commodities form (figure 10.2.1) allows the user to specify up to eight commodities to be used when the Custom option is selected from the Commodities dropdown list on the General Information form (10.1.2)

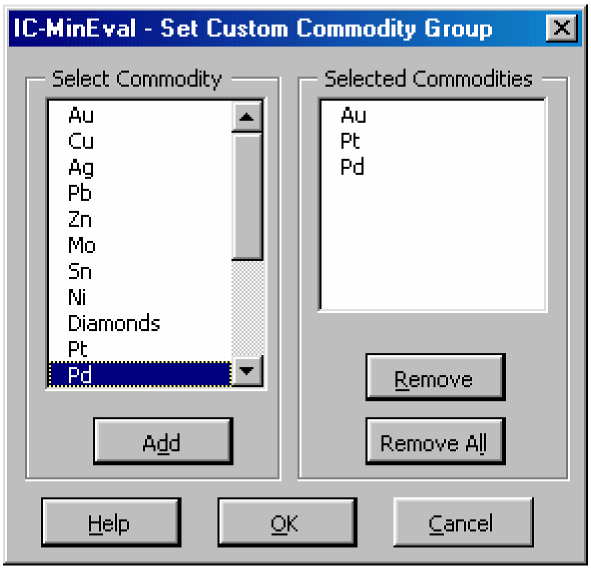

Figure 10.2.1: Custom Commodity Selection

By Selecting the commodities from the left window, the user can add up to 8 commodities to the custom group and can include the same commodity more than once, in case the user needs to specify more than one industrial mineral or has the same commodity at different grades. The range of commodities that can be added include: Au, Cu, Ag, Pb, Zn, Mo, Sn, Ni, Diamonds, Pt,

Pd, Rh, Ir, Ru, Os, Coking, Steam, Anthracite, Industrial Mineral, Rutile, Ilmenite, Garnet, Zircon, Co and U_3O_8 (Uranium).
If a commodity has been added in error, it can be removed by selecting it in the right window and clicking *remove*. Clicking *remove all* will remove all the commodities from the right window. If the mineral you require is absent from the list, select a mineral with the same units of production and sale e.g g/t and $/oz with Industrial mineral being a straight % of extraction and sold in units of $/t.

10.1.3 Resources

The *Resources* menu (figure 10.3) is used to set the size of the deposit, the grades and several other mining parameters. If working on a polymetalic deposit the grades and plant recovery for the various metals will be displayed on a tab strip and a particular metal can be selected by clicking on that metals name.

Ore Body Model

Total Mineralised Volume

This is the total volume of the deposit. This is multiplied by the specific gravity of the ore to calculate the *Total Insitu Ore at cut-off = 0* (the total ore tonnage).

Specific Gravity of Ore

The specific gravity of the ore will vary depending upon the deposit type. This is multiplied with the total mineralised volume to determine *Total Insitu Ore at cut-off = 0.*

Mining Recovery (%)

The mining recovery is the percentage of the total in-situ ore that can be mined. Some areas of the orebody may not be amenable to extraction or a particular mining method e.g. room and pillar may not be able to extract all the ore. The Mining Recovery is multiplied by the *Total Insitu Ore at cut-off = 0* to determine the *Total Ore Recovered.*

% Tonnage Dilution (grade = 0)

The dilution is the amount of waste rock (material whose grade is below cut-off) that is mined as ore. In **IC-MinEval** this material is considered to have 0 grade.

Stripping Ratio (O: W)

This is the amount of waste material that has to be removed for every tonne of ore mined in *Open Pit* operations.

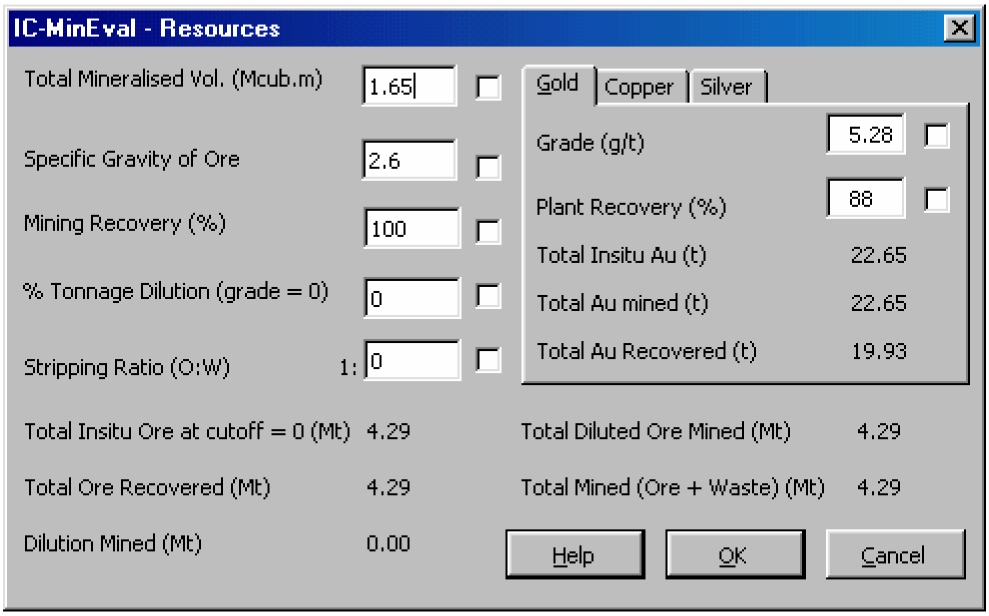

Figure 10.3: Resources.

Commodities

Grade

This is not the cut-off grade (minimum economic grade), but the *average grade* of the ore mined, and should normally be higher than the cut-off grade.

Plant Recovery

This is the percentage of the metal contained in the ore that can be recovered by processing through the plant.

10.1.4 Mining Rates

The *Mining Rates* menu (figure 10.4) sets the rate at which the ore body is mined. This is important because it directly effects the mine life and the Capex as the more rock mined per year, the larger the processing plant and equipment that is required.

Mining Rate
Estimate Mining Rate
Select this option if you wish to enter the known or your own estimate of the mining rate.
Mining Rate /Day (T)
This is the amount of material that is mined per day. This includes waste material, so in an open pit operation, the relationship with the amount of ore mined per day depends on the stripping ratio.
Calculate Mining Rate Using Taylor's Formula
Select this option if you wish to use Taylor's formula to estimate the mining rate. Taylor's Formula calculates an approximate rate based on published data.
Exp. Mining Factor
This is the factor used in Taylor's formula. This is usually 0.78, but as this tends to underestimate the optimum mining rate, you can alter the factor here.
Work Days / Year
The number of days per year that mining occurs. This is multiplied by the mining rate to determine the total mined per year, the total ore mined per year and from these the mine life.

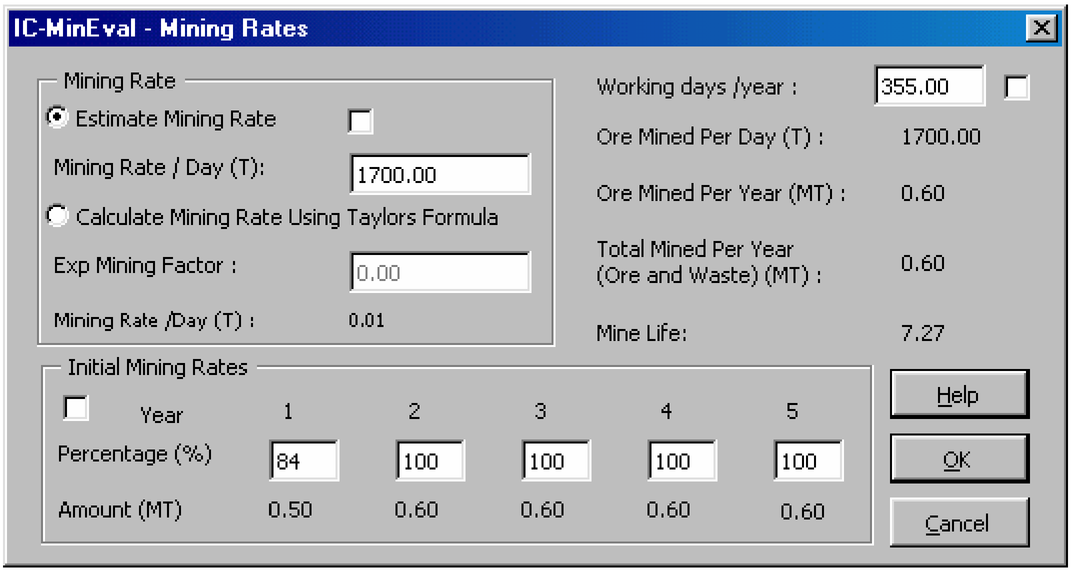

Figure 10.4: Mining Rates.

Initial Mining Rates
This allows you to vary the initial mining rates over the first five years of production, to simulate a ramp-up period. The value entered is a percentage of the mining rate.

10.1.5 Costs

The costs menu (figure 10.5) sets the Capex and Operating costs for the current project. If these are known or you have a good idea what they will be from similar operations, they can be entered directly as values. However, if you do not have a reasonable idea what these will be, you can use the *calculate option* to determine a rough cost from the empirical formulae produced by O'Hara (1980).
These formulae were produced in the late 1970's based on studying cost data from Canadian projects. In this version of **IC-MinEval**, O'Hara formulae are available for *open pit* Capex and operating costs, and *underground* Capex gold projects. In the final version it is hoped to have these available for different metals and underground mining methods.

Capex
Capital Costs (Capex) are costs in a particular year that will produce benefits in later years.
Calculate Capex
Select this option if you wish to use the recalibrated O'Hara's formulae to calculate Capex.
Ratio in construction Canadian mines and proposed location
As the formulae were calculated using Canadian data, you may wish to multiply them by a factor if the Capex varies between the location of your project and Canada. A ratio of one gives the same Capex costs as Canada, less than one reduces the Capex, whilst a value greater than one will increase the Capex.
Estimate Capex
Select this option if you wish to enter your own Capex values. The total Capex is calculated as:
(Capex Mine/ Mill + Capex Processing Plant) x Overhead Costs
Capex Mine/ Mill (M$)
This is the cost of constructing the mine site and mill.
Capex Processing Plant (M$)
This is the cost of constructing the processing plant.
Overhead Costs (% of Capex)
This covers additional costs and expenses that will be incurred and is entered as a percentage of the Capex.

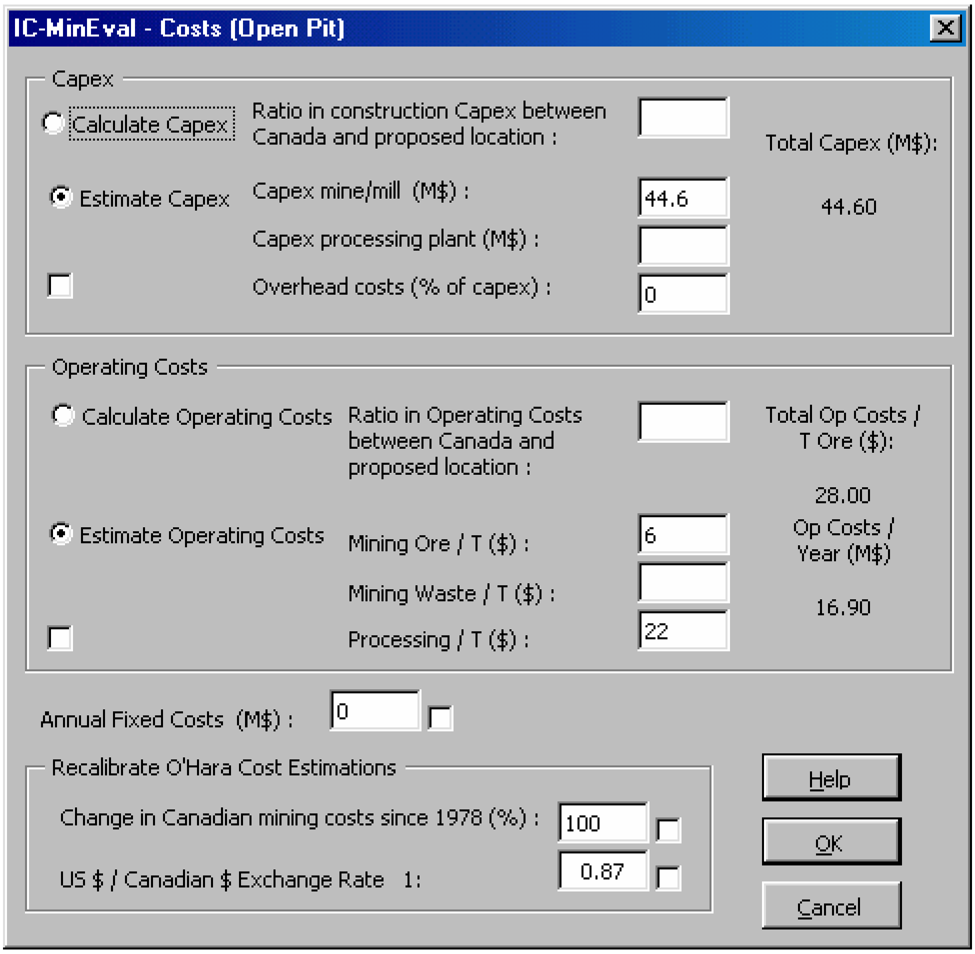

Figure 10.5: Costs.

Operating Costs

Operating Costs (OpCosts) are costs that only produce a benefit for that year and are calculated annually.

Calculate Operating Costs

Select this option if you wish to use the recalibrated O'Hara's formulae to calculate the operating costs.

Ratio in Operating Costs between Canadian mines and proposed location

This is the same as for Capex, but is applied to the calculated operating costs.

Estimate Operating Costs

Select this option if you wish to enter your own operating costs. The total operating cost per tonne of ore is calculated as:

Cost of mining one tonne of ore + (Cost of mining one tonne of waste x Strip Ratio) + Cost of processing one tonne of ore.

Mining Ore ($/T)

Cost of mining one tonne of ore.

Mining Waste ($/T)

Cost of removing one tonne of waste. This is normally lower than the cost of mining ore as it is often not sampled.

Processing ($/T)

Cost of processing one tonne of ore.

Annual Fixed Costs (M$)

Additional fixed costs per year.

Coal Mining Only
Transport Costs /T ($)
Where any of the three coal types is selected as a commodity an additional cost component is added for transporting the coal and is calculated in $ per tonne transported.

Recalibrate O'Hara Cost Estimations
Change in Canadian Mining Costs Since 1978(%)
As the O'Hara formulae were calculated using 1978 data based in Canada, this allows you to inflate the 1978 costs to the current value. This value is entered as a percentage and is multiplied to the Capex and Operating Costs.
US$ / Canadian $ Exchange Rate 1:
As the O'Hara formulae were calculated in Canadian dollars, if you wish to use the formulae you will need convert them into US$. The exchange rate in 1978, when the original calculations were made, was 1 US$ to 0.87 Canadian $.

If you do not know the individual costs, you can just enter a single value in either the cost of mining ore or in the cost of processing and set the rest to zero. In such a case don’t enter the value in the cost of mining waste, as the value will be multiplied by the strip ratio.

10.1.6 Commodity Prices

The *Commodity Prices* menu (figure 10.6) lets you set the sale price of your product, how the price will vary over the project life and set the hedging price, if any. Each metal has a separate tab, which you select by clicking on the name.

Spot Price
This is the value sales of the metal will get on the open market.
Price
This is the price at the start of the project.
Inflated
Selecting this option increases the metal price by the rate of inflation each year.
Fixed
Selecting this option keeps the metal price constant over the project's life.
Escalated
Selecting this option allows you to set the rate of increase or decrease in metal price each year.
Annual Escalation (%)
This is the rate of increase (positive) or decrease (negative) in the metal price as a percentage. The effects of this escalation are cumulative.

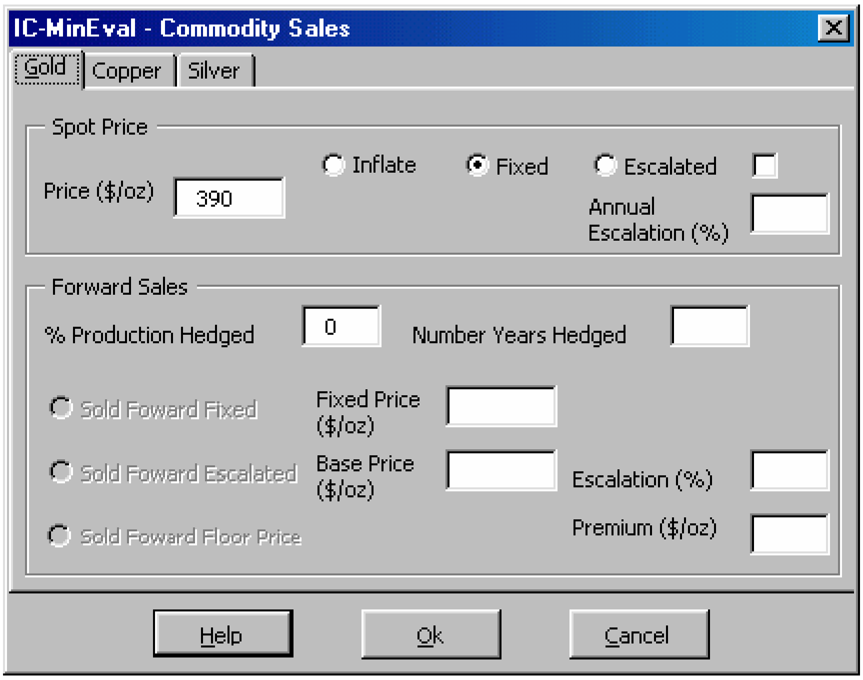

Figure 10.6: Commodity Prices.

Forward Sales
This allows you to sell a percentage of your production at a different price (hopefully higher) to the spot price.
% Production Hedged
This is the percentage of your annual production that you are selling at the hedged price.
Number Years Hedged
This is the number of years that you have arranged to sell some of your production at the hedged price.
Sold Forward Fixed
Select this option if the hedged price is fixed over the contract period.

Fixed Price
This is the fixed price you will get for the metal.
Sold Forward Escalated
Select this option if the hedged price increases or decreases by a set rate over the contract period.
Base Price
This is the initial contract price.
Escalation (%)
This is the rate the contract price will vary over the contract period.
Sold Forward Floor Price
Select this option if you will always receive a fixed premium on the floor price.
Floor Price
This is the base price.
Premium
This is the premium you will receive on top of the floor price.

10.1.7 Expenditure

The *Expenditure* menu shown in figure 10.7 is used to spread the Capex payments over the first five years of the project and to set up the amount of working capital to be used.

Capex Payments
The Capex is unlikely to all be employed in the first year of the project, depending upon delays and the construction period. This menu allows you to spread the capital expenditure over the first few years of the project.
Percentage
This is the percentage of the total Capex spent in a particular year. The sum of all five years must be equal to 100.

Working Capital
Working Capital (% of Annual Op Costs)
This is used to set the amount of working capital required. This is expressed as a percentage of the annual operating costs and is normally set at around 25%.

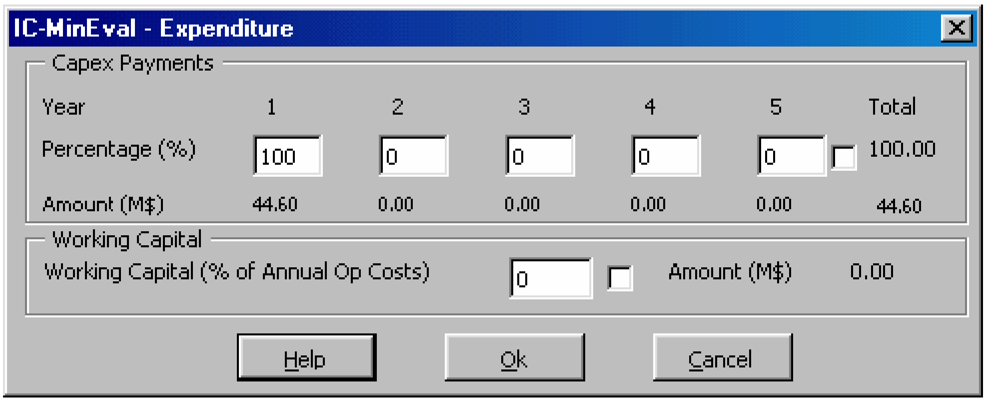

Figure 10.7: Expenditure.

10.1.8 Environmental and Closure Provision

The *Environmental and Closure Provision* menu (figure 10.8) allows you to include the expected environmental costs and additional costs associated with the project's closure within your appraisal.

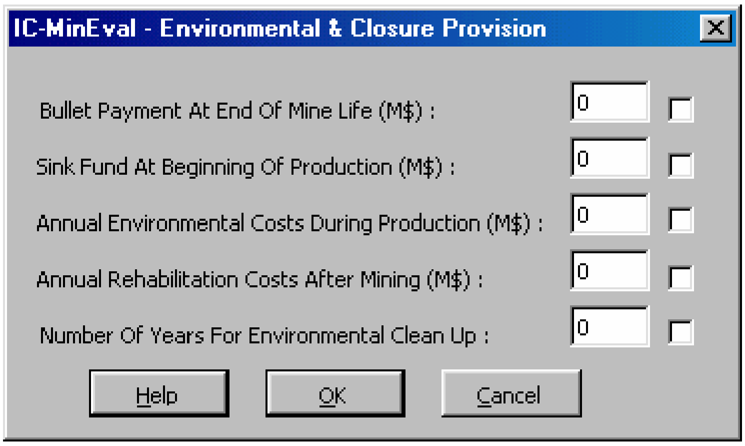

Figure 10.8: Environmental and Closure Provision.

Bullet Payment At End Of Mine Life (M$)
This is a fixed amount which is payable at the end of the mine life to pay for the environmental rehabilitation of the mine site, retrenchment costs etc.

Environmental Sink Fund at Beginning of Production
This is a fixed amount which is payable before the start of production and acts as an environmental bond to cover the cost of the environmental rehabilitation of the mine site.

Annual Environmental Costs During Production (M$)
This covers on-going annual environmental costs during production.

Annual Rehabilitation Costs After Mining (M$)
This is the annual cost of rehabilitating the mine site and is not included in either the sink or bullet payments that have been made.

Number of Years for Environmental Clean Up
Essentially the length of time after the completion of mining that the annual rehabilitation costs have to be paid.

10.1.9 Financial

The *Financial* menu (figure 10.9) sets the basic financial parameters such as the tax and inflation rate, depreciation etc.

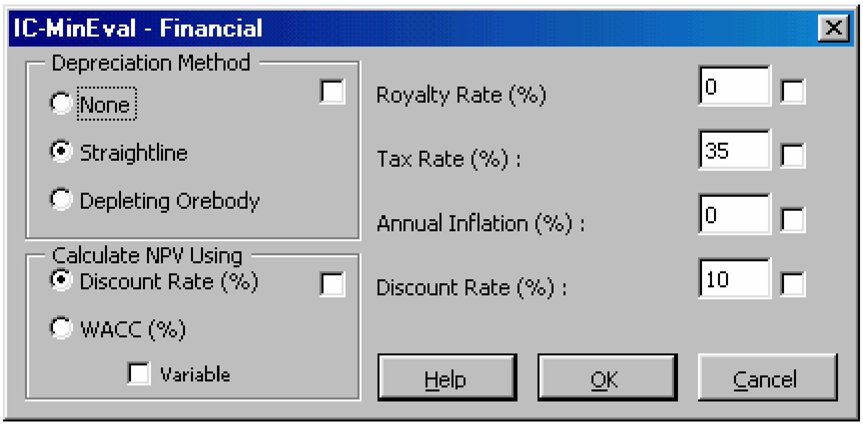

Figure 10.9: Financial.

Royalty Rate (%)
The royalty rate is a tax applied directly to the revenue, before the operating costs are taken into consideration. Royalties are usually paid on sales of minerals extracted from the land to the landowner or government who have granted the mineral rights to the project.
Tax Rate (%)
This is a flat rate of tax applied directly to the cash flows.
Annual Inflation (%)
This is the annual rate of inflation. The rate of inflation is applied to the costs and can be applied to the metal sale price if so selected in the *Commodity Prices* menu.
Discount Rate (%)
This is the discount rate used to calculate the Net Present Value (NPV).

Depreciation Method
This option allows the method used to depreciate the tangible fixed assets (Capex) for tax purposes.
None
The Capex is not depreciated over the life of the mine.
Straight line
The Capex is depreciated at a constant rate over the mine life. The Capex is depreciated by:

$$\frac{\text{Total Capex}}{\text{Mine Life}} \text{ each year}$$

Depleting Ore body
The Capex is depreciated by a variable rate as the ore body is mined. The annual depreciation is calculated as:

$$\frac{\text{Ore Mined in Year}}{\text{Total Reserves} * \text{Mining Recovery}}$$

Calculate NPV Using
This provides you with two methods of setting the discount rate used to calculate the NPV.

Discount Rate (%)
Uses the discount rate entered in the adjacent box.
WACC (%)
Uses the weighted average cost of capital. This is calculated as:

Weighted Average Cost of Capital
=
(Tax Adjusted Cost of Debt x Percentage Debt)
+
(Cost of Equity x Percentage Equity)

As the NPV is calculated on the cash flows before funding but after tax, an allowance is made for the tax implications of interest payments on debt. Interest payments on debt act as a tax shield. In **IC-MinEval** the cost of debt is calculated as:

Tax adjusted Cost of Debt = Interest Rate x (1 – Tax Rate)

See section *10.1.10 Project Finance* for calculating the weighted average cost of capital and the cost of equity.
Variable WACC
Selecting variable WACC changes the WACC as the Debt/ Equity ratio changes as loan repayments are made.

10.1.10 Project Finance

Investment banks use a particular type of lending called Project Finance when funding the development of a mining project. The loan is repaid from the cash flows generated by the project with no recourse, or only limited recourse, to the parent company. Project finance thus allows the sponsor to risk less of its own funds without diluting its equity investment in the project. The cost of debt capital is usually less than the cost of equity, producing a lower WACC for the project and maximising the resulting NPV (see *10.1.9*). Interest charges on debt and loan repayments can both serve as tax shields, thus off-setting the negative effect of debt servicing on the project's cash flows (see *wshtTax*, *10.2.6*).

The *Project Finance* menu (figure 10.10) is used to set up the financing structure of the project, including the amount of debt and equity, interest rate and repayment schedule. It allows you to refine the financial model and explore the impact debt finance has on the project economics. The menu allows you to manually input the amount of funding to be drawndown each year (see *Amount*), though **IC-MinEval** can automatically undertake all necessary financial engineering to optimise the scale and schedule of funding*. The *Project Finance* menu should be left blank if the project is to be funded entirely by equity.

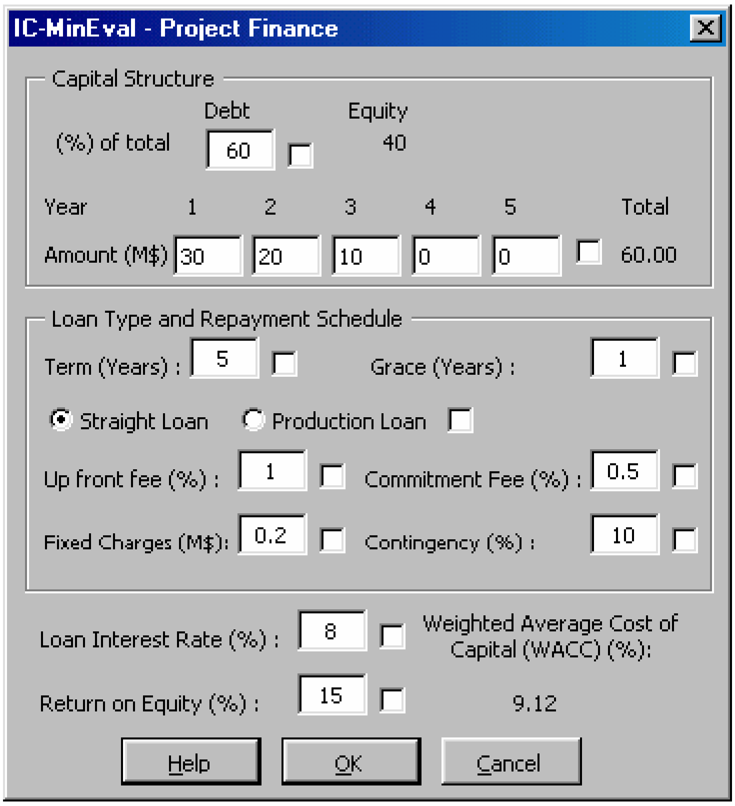

Figure 10.10: Project Finance

Capital Structure

This option is used to set the Debt/ Equity ratio and the size of the debt.

% of Total

This is the percentage of the total finance required that will be funded as debt. If the project is to be completely equity financed, then this value should be set to 0.

Amount (M$)

This allows you to set the total amount of funding (debt and equity) required by the project and the drawdown can be set over the first five years of the project. The first year is the same as the first pre-production year (if any).
**Note: If you wish to calculate the amount of funding required by the project with the given debt/equity ratio and interest rates etc., you can do this automatically by selecting the Funding button on the main menu (see section 10.1.1).*

Loan Type and Repayment Schedule
Term (Years)
Essentially the number of loan repayments to be made.
Grace (Years)
The number of years, post construction completion, before loan repayments have to be made.
Loan Type
Straight Loan
The loan repayments are in equal instalments
Production Loan
The loan repayments are proportional to the production rate i.e.:

$$\text{Repayment} = \frac{\text{Annual Production}}{\text{Total Production During Loan Repayment}}$$

Up Front Fee (%)
These are the charges set by the financier for arranging the loan etc, and are a percentage of the total loan available. These fees are incurred at the start of the project.
Commitment Fee (%)
This is an annual fee charged on the amount of the loan that has not been used (drawndown).
Fixed Charges (M$)
These are charges incurred for agents and trustee's fees, legal documentation, independent completion engineers, independent reports.
Contingency (%)
An additional percentage of the total required funding to act as a cushion against unexpected cost rises etc.

Loan Interest Rate (%)
This is the annual rate of interest on the debt.
Return on Equity (%)
This is the annual expected return on equity invested. This can be calculated by a variety of methods including the *Capital Asset Pricing Model* (CAPM).

10.1.11 Multi Partner

Projects often involve multiple stakeholders, each with their own investment criteria and expected returns. The Multi-Partner module allows each stakeholder to calculate their expected return from the project based on their level of participation and can include stakeholders with a free carry such as Black Economic Empowerment (BEE) groups.
The *Multi Partner* menu (figure 10.11) is used to structure the participation level of up to three stakeholders and set rate of cash returned to each.

Equity Structure
Investment Amount (%)
This is amount invested by each partner as a percentage of the *Total Equity Funding* (see Project Finance, 10.1.10). The actual amount is displayed below in M$ and if any stakeholder has a free carry then the % should be left at zero, although the total must equal 100%.

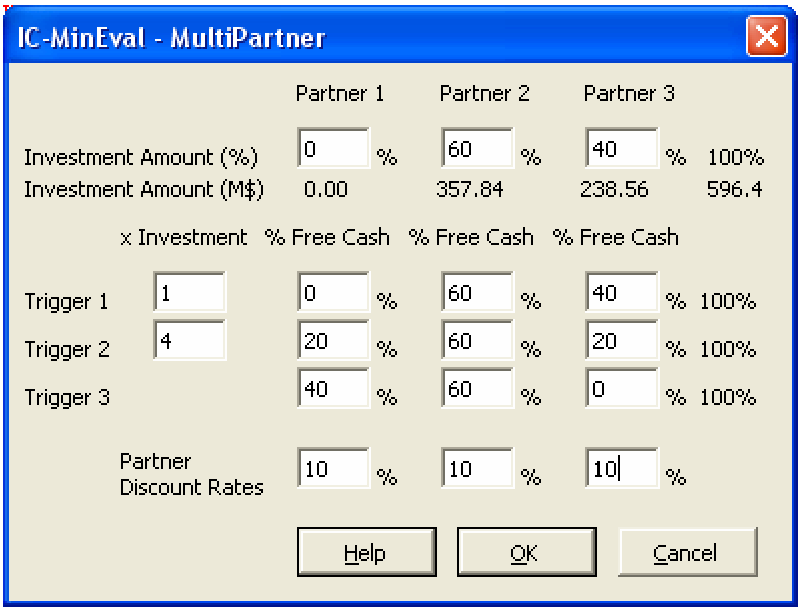

Figure 10.11: MultiPartner

Return of Cash
The return of cash to each stakeholder is based on two criteria: the *Trigger* and the *% Free Cash*.
% Free Cash (%)
This is the amount of free cash (After Funding and Debt Service) that each stakeholder receives and the total must equal 100%. This amount can be varied by setting different rates for different triggers.
Trigger
You can set up to two triggers to change the distribution of free cash to each stakeholder. A trigger is based on the total amount of free cash distributed to stakeholders relative to the total equity investment amount.
For example in the example shown in figure 10.11, the total equity investment by all stakeholders was 596.4M$. As trigger 1 was set to one, the free cash back to three stakeholders would be distributed at 0%, 60% and 40% up until 596.4M$ in total had paid (1 x 596.4). At this point the free cash would be distributed 20%, 60% and 20% up until a total of 2385.6 M$ (4 x

596.4 and includes the amount distributed through trigger 1). From then on the cash is distributed 40%, 60% and 0% until the end of the project.

Discount Rate (%)

This is the discount rate used to calculate the after tax and debt service NPV for each stakeholder and can be different for each one.

10.2 worksheets

The worksheets produced are a set of Excel spreadsheets that detail how the financial model is built up from the initial inputs through the resources, the production schedule, revenues and tax charges to produce the DCF worksheet fully linked into the P&L and Balance sheets.

10.2.1 wshtInputData

The *wshtInputData* is used to store all the variables and other data used to calculate the DCF model (*wshtDCF*) and is linked to all the other worksheets. All the variables are referenced using *Names* rather than cell references and most of the names used by **IC-MinEval** are defined in this sheet. When you save an **IC-MinEval** data set, *wshtInputData* is saved to a separate file. It is important that you only try to load saved data sets using **IC-MinEval** otherwise the names will not be defined properly and errors will occur. The input sheet contains values, formulae and text, which can be confusing. To enable you to identify which variables you can change it is possible to colour code the contents of the input sheet by selecting *Colour Inputs* (section 10.1.1) on the main menu.

10.2.2 wshtReserves

The *wshtReserves* worksheet calculates the depletion of the orebody using the mining rate. The calculations include dilution and work out the amount of ore and waste mined per year over the mine life. This sheet allows you to analyse the efficiency of the mining process itself.

10.2.3 wshtRevenue

The *wshtRevenue* worksheet calculates the amount of each metal mined per year, the revenue from each metal and the total revenue per year over the mine life. This sheet thus allows analysis of the contribution of each of the metals mined to the total revenue produced by the mine. For single metal gold mines, the operating cost per ounce of gold produced is also calculated and displayed on this worksheet.

10.2.4 wshtCosts

The wshtCosts worksheet is used for Capex and Operating Cost calculations and estimates. If the user has their own cost data it should be incorporated here, either directly or by linking to their cost data. This sheet allows you to directly analyse the capital and annual operating costs of the project and shows how these costs are generated by unit operation.

10.2.5 wshtE&C

The *wshtE&C* worksheet is used to calculate the provisions made for environmental and closure costs, including capital and annual costs. The rows named *TotalAnnualOpCosts* and *TotalCapex* are then taken and used in the DCF model. This sheet allows you to analyse the total environmental costs of the project.

10.2.6 wshtTax

The *wshtTax* worksheet is used to calculate the amount of tax payable both *before* (for the purposes of calculating *NPV* and *IRR*) and *after* funding (to take account of tax shields and calculate the actual *payable tax*). Tax *before* interest is calculated after deducting annual depreciation from the annual net income. However, when debt financing is involved, the actual *tax payable* is calculated *after* annual interest charges and any financing costs have also been deducted. Tax payable is automatically transferred to the *wshtDCF* and *wshtP&L* (*10.2.8*) worksheets where the impact on cash flow and profit can be seen.

You can add additional rows and enter your own tax on *wshtTax* to create your own custom tax calculations. These can be saved and later reloaded as pre-built custom tax sheets from the *files* menus (section *10.3.3*). The values of the rows named in *Excel* as *Tax* and *TaxAfterFunding* are taken to *wshtDCF* to calculate the cash flows after tax, and so your final tax payable should be calculated in these rows (see *Appendix A – Producing Custom Tax Models*).

10.2.7 wshtFinance

The *wshtFinance* worksheet allows you to fully analyse the financing structure of the project. This sheet calculates the total amount of debt and equity required to finance the project and can be used to adjust the drawdown schedule for this funding. From this the interest and repayment schedules can be calculated. *WshtFinance* thus allows analysis of the optimum drawdown amount each year (to ensure there is never a negative *after funding* cash balance in any particular year), and this can be calculated automatically by **IC-MinEval** using the *Funding* option on the main menu (see *10.3.2*).

This worksheet also calculates several financial ratios that are important tools in the analysis of project financings. These include the *Debt Service Ratio*, *Loan Life Ratio*, *Project Life Ratio*, *Cash Cover (Debt Service Coverage)*, *Reserves Tail Ratio*, *Interest Cover Ratio*, *Principal Cover Ratio and the Residual Cover* (see *Appendix B – Financial Ratios*). These ratios are widely used by investment banks and can be graphed by selecting *chart* on the main menu (see *section 10.3.2*).

10.2.8 wshtP&L

The *wshtP&L* worksheet contains the projected Profit and Loss accounts generated from the DCF and Balance sheets. This sheet follows formal accounting formats and analyses the project's ability to generate profit over each year of the projected mine life.

10.2.9 wshtBalance

The *wshtBalance* worksheet contains the projected Balance sheets for the project. This sheet follows formal accounting formats and allows analysis of the projected financial state of affairs at the end of each year of the mine life

10.2.10 wshtSensitivity

This worksheet displays the results of running a sensitivity analysis (see *section 10.3.1*), and these results are plotted on the *sensitivity* chart.

10.2.11 wshtMultiPartner

The *whstMultiPartner* calculates the NPV and IRR for up to three partners based on the criteria entered in the Multi Partner form described in section 10.1.11. It lays out each trigger point as well as the cash flow for each stakeholder before calculating the NPV and IRR. Note that if a stakeholder has a free carry, then logically you will be able to calculate the IRR.

10.2.12 IC-MinEval Options

This worksheet stores the settings used to customise the updating of the model as described in section 10.3.5 Settings.

10.2.13 wshtDCF

The main Discounted Cash Flow (DCF) calculations are carried out on this sheet which takes data from most of the other worksheets.

10.3 Additional Controls

Analyse Model

10.3.1 Sensitivity Analysis

The *Sensitivity Analysis* menu (figure 10.11) is used to generate spider graphs to show how the viability of a project is effected by changes in key parameters. The calculations are made on *wshtSensitivity* (see *10.2.9*) and the resulting spider diagram is displayed in *Sensitivity* (figure 10.14) to allow graphical analysis of the project's sensitivity. Once you have selected all the required variables, you can run the sensitivity analysis by clicking on *Ok*.

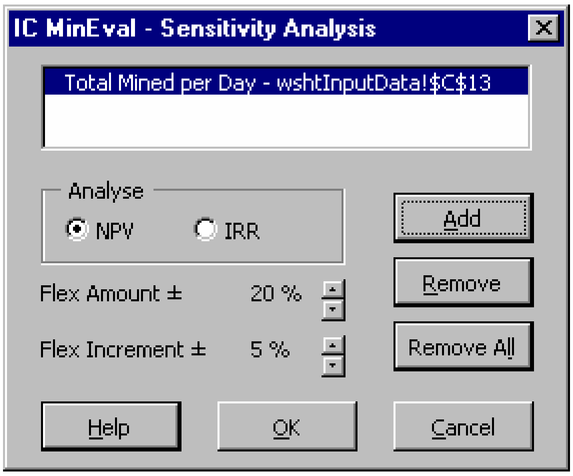

Figure 10.11: Sensitivity Analysis.

Add
Clicking on the *Add* button allows you to add a variable to the list of parameters to be analysed in the sensitivity analysis (up to a maximum of 20). Clicking on this button allows you to select the variable and assign a name to it (see *Figure 10.12*).

Remove
If you wish to alter or remove one of the variables you have entered just select it from the list and click on *Remove.*

Remove All
If you wish to remove all the variables from the list, just click on *Remove All.*

Analyse
Spider diagrams can be produced to compare the various variables against either the NPV or the IRR. To choose either, just highlight the associated option button

Flex Amount
The flex amount is the maximum positive and negative variation in a variable that will be calculated and displayed on the spider diagram.

Flex Increment
This is the amount of variation that will be calculated up to the maximum flex amount for each variable to be analysed.

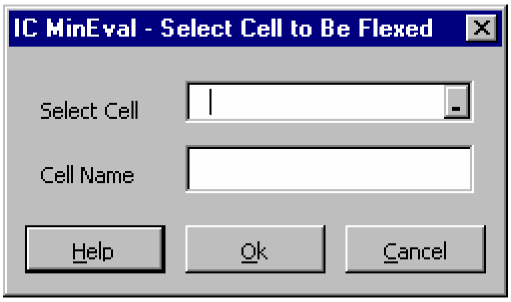

Figure 10.12: Sensitivity Analysis.

Selecting *Add* on the sensitivity analysis form displays the variable selection form shown in figure 10.12.

Select Cell
This is a special type of input box that, as well as allowing the cell reference to be entered as text, also lets you actually select a cell by clicking on it in the worksheet (see *figure 10.13*). When selecting a cell you can click on the worksheet tabs to change sheet and you may select variables from more than one sheet. However, you can only select one cell at a time and cannot select a range of cells.

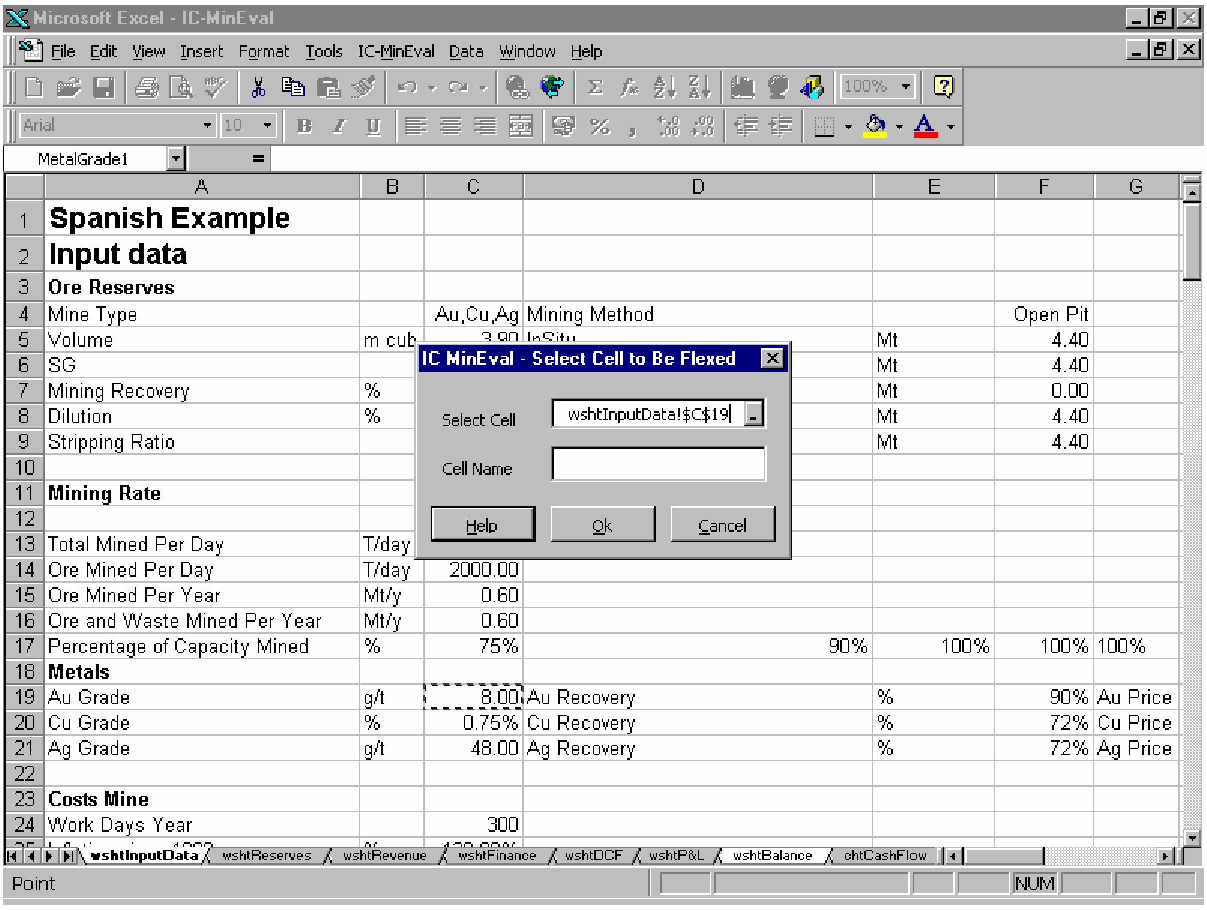

Figure 10.13: Selecting a cell to be flexed by clicking on it in the worksheet.

Cell Name

This is the parameter name that will be displayed in the legend of the sensitivity analysis spider diagram.

Spider Diagrams
Once the sensitivity analysis module of **IC-MinEval** is run a spider diagram is produced in the *Sensitivity* chart (Figure 10.14). The spider diagram compares the percentage change in a parameter against the percentage change in either the *IRR* or *NPV*.

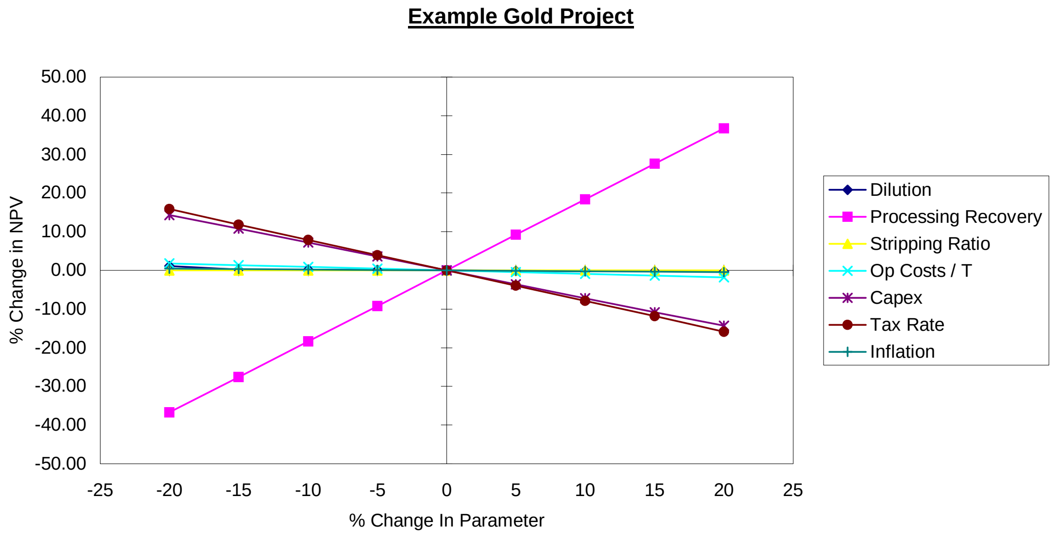

Figure 10.14: Sensitivity.

10.3.2 Funding

The *funding* option automates the calculation of the minimum level of funding required in order to ensure that there is never a negative cash balance (plus funding contingency) at the specified Debt/ Equity Ratio in any given year. This is done by changing the total funding amount each year so that the cash balance in that year is not negative, taking into account the effect of interest payments.

The *funding* option is a major tool in the modelling of project finance. Calculating the optimum amount and schedule of funding can be a complex and time-consuming task for investment bankers. Selecting this option triggers **IC-MinEval** to automate all the necessary financial engineering to ensure that the project's cash balance remains positive throughout the initial period of capital expenditure on development.

10.3.3 Charts

The charts menu (*figure 10.15*) allows you to select the cash flows or ratios you require and display them as either a bar or scatter line chart, with or without data labels.

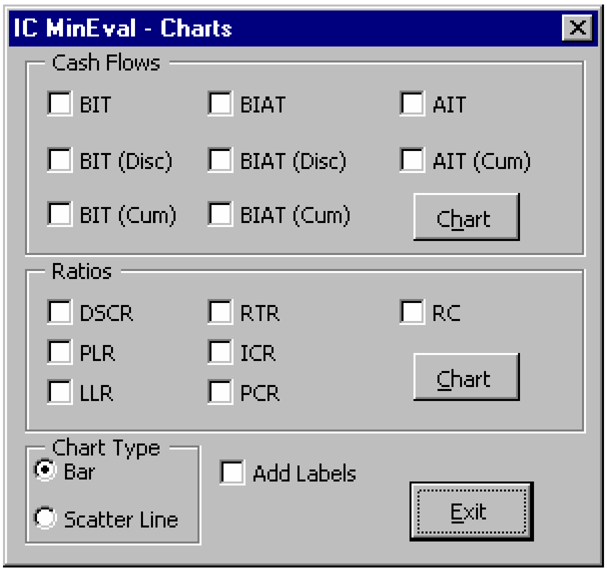

Figure 10.15: The charts menu.

You can display multiple cash flows or ratios on the same chart, but not mix them both. The different cash flows are taken from *wshtDCF* and are as follows:

Before Interest and Tax
Discounted Before Interest and Tax
Cumulative Before Interest and Tax
Before Interest but After Tax
Discounted Before Interest but After Tax
Cumulative Before Interest but After Tax
After Interest and Tax
Cumulative After Interest and Tax

The ratios are taken from *wshtFinance* and are described in section *10.2.7 wshtFinance*. They are as follows:

Debt Service Cover Ratio
Project Life Ratio
Loan Life Ratio
Reserves Tail Ratio
Interest Cover Ratio
Principal Cover Ratio
Residual Cover

Chart Type
You can change the type of chart displayed by selecting either *Bar* or *Scatter line*.

Add Labels
Selecting this check box adds data labels to each point on the Chart.

Once you have selected the parameters and the type of chart you require, select the corresponding *Chart* button. If you do not wish to continue select *Exit* to return to the main menu.

Selecting *Chart* displays the selected chart as in figure 10.16. If you like the displayed chart you can add the chart into the current model as an *Excel* chart by selecting *Add to Excel*, where you can edit it further. Otherwise just select *Exit* to return to the main menu.

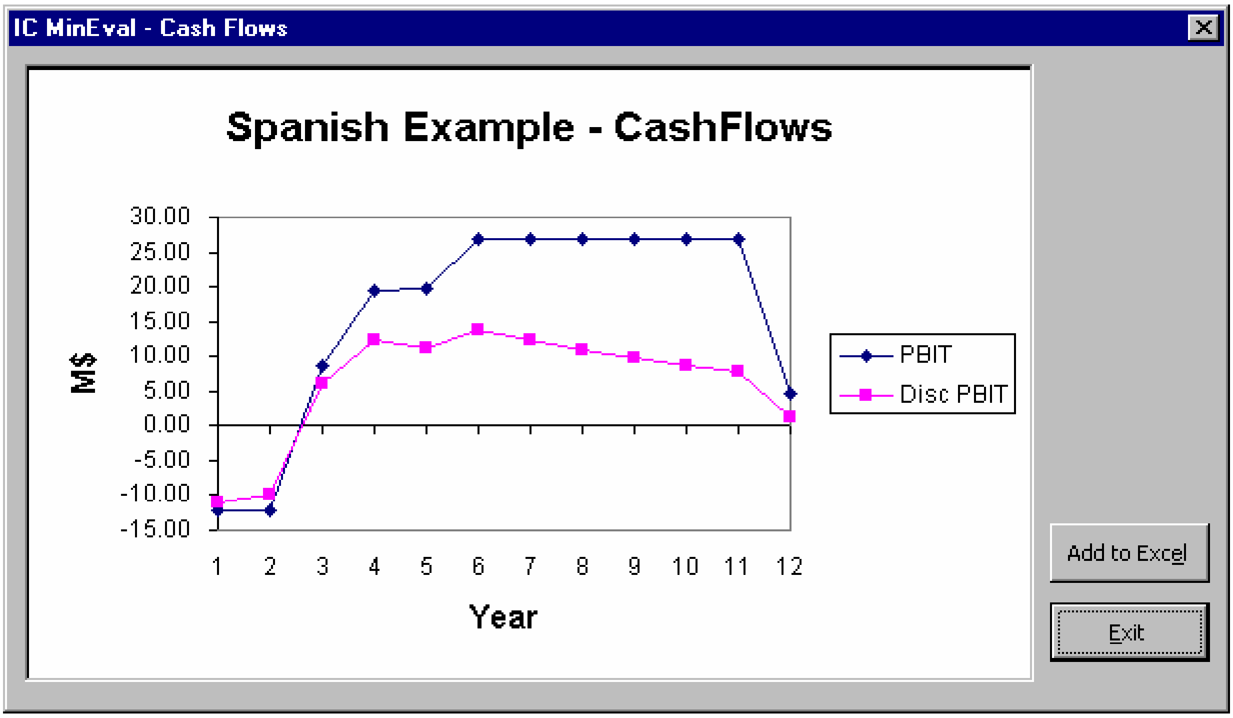

Figure 10.16: The Cash Flows chart display.

10.3.4 Files

The files form (Figure 10.17) allows the loading and saving of **IC-MinEval** data sets and custom tax sheets.

Figure 10.17: The Files form.

Data Set
Load Data
This button allows you to load a previously saved data set (See section *10.3.3.1 Load Dataset*).
Save Data
This button allows you to save the current *wshtInputData* as an IC-MinEval data file (see section *10.3.3.2 Save Dataset*).

Tax
Load Tax
This button allows you to load a previously saved Tax sheet (see section *10.3.3.3 Load Tax*).
Save Tax
This button allows you to save the current *wshtTax* as an **IC-MinEval** Tax data file (see section *10.3.3.4 Save Tax*).

Help
Displays the *Files* section of the help file.
Cancel
Closes the form and returns to the *main menu*.

10.3.3.1 Load Data set
If you have previously saved a project using *Save Data set*, you can re-load it using the *Load Data set* button from the *Files Menu*. You will be prompted for the filename by the *Load Data set* dialog box (figure 10.18).

Note: The file you load must have been previously saved using *Save Data set* otherwise you may experience errors in the model.

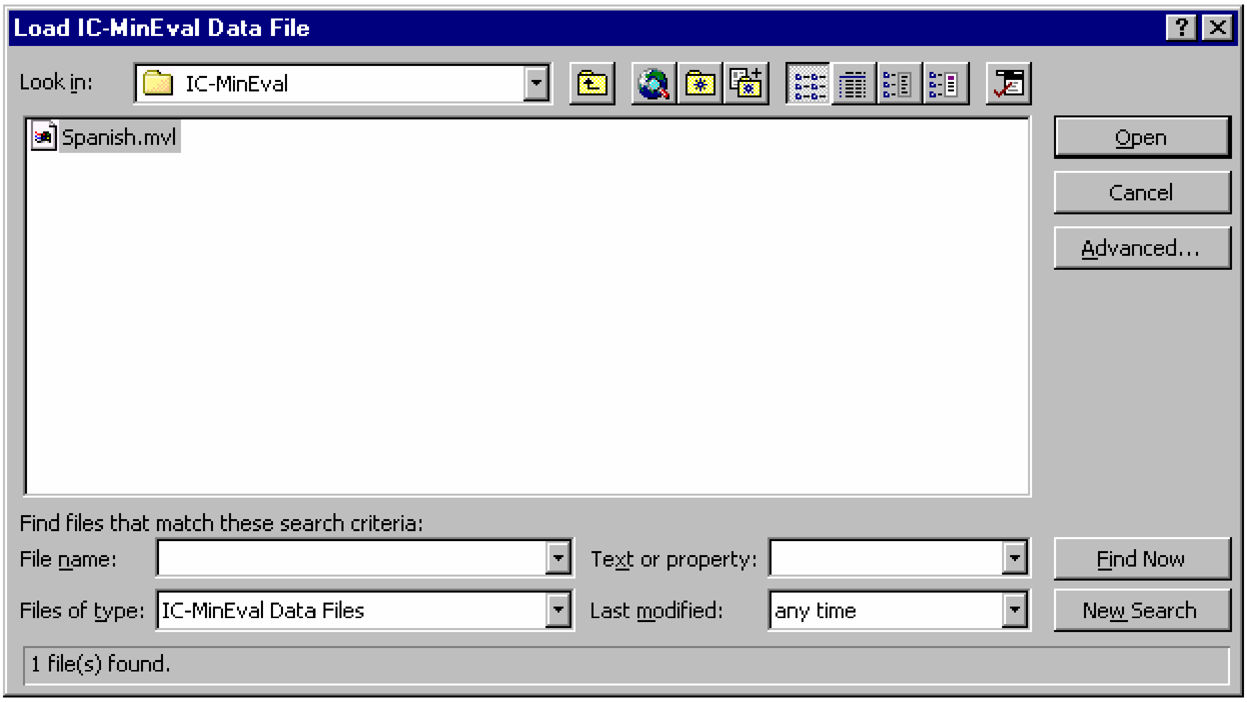

Figure 10.18: Load Dataset.

10.3.3.2 Save Data set

Once a project model has been produced it is possible to save the value of all the input variables in a project file. Selecting *Save Data set* (figure 10.19) from the *Files Menu* will produce a form prompting the user for a file name. The default name will be the first 8 letters of the project name defined in the *General information* menu. The file produced will have the extension .mvl and will be an Excel workbook with *wshtInputData* containing all the input variable settings and all the name definitions.

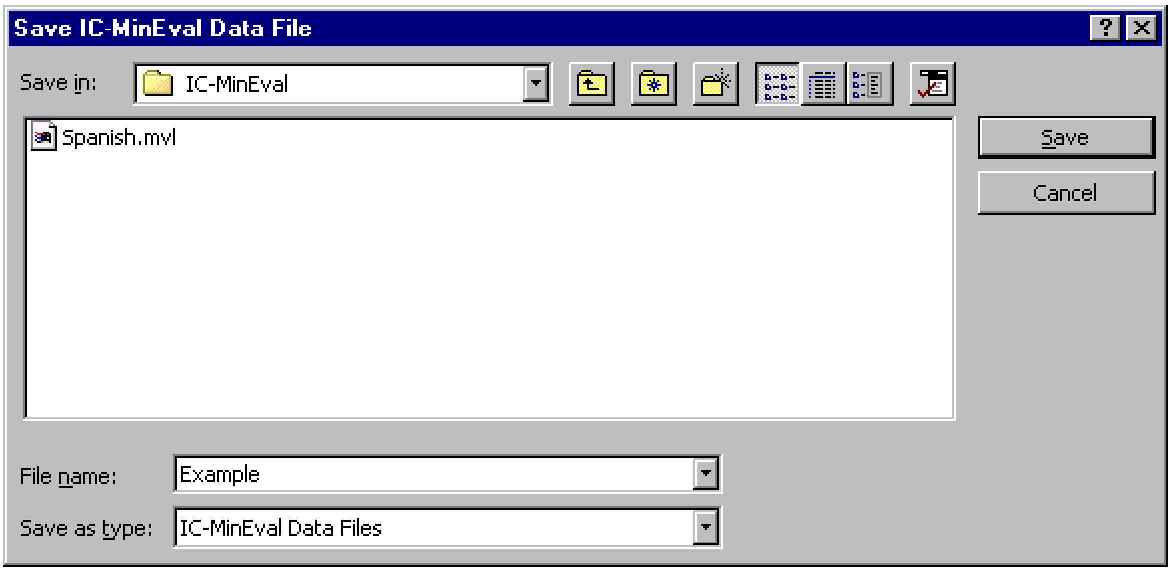

Figure 10.19: Save Dataset.

10.3.3.3 Load Tax

If you have previously saved a custom tax sheet using *Save Data set* or have a pre-built tax sheet produced by IC-FinEval, you can re-load it using the *Load Tax* button from the *Files Menu*. You will then be prompted for the filename of the tax sheet by the *Load TAX* form (figure 10.20).

Note: The file you load must have been previously saved using *Save Tax* otherwise you may experience errors in the loading the tax module.

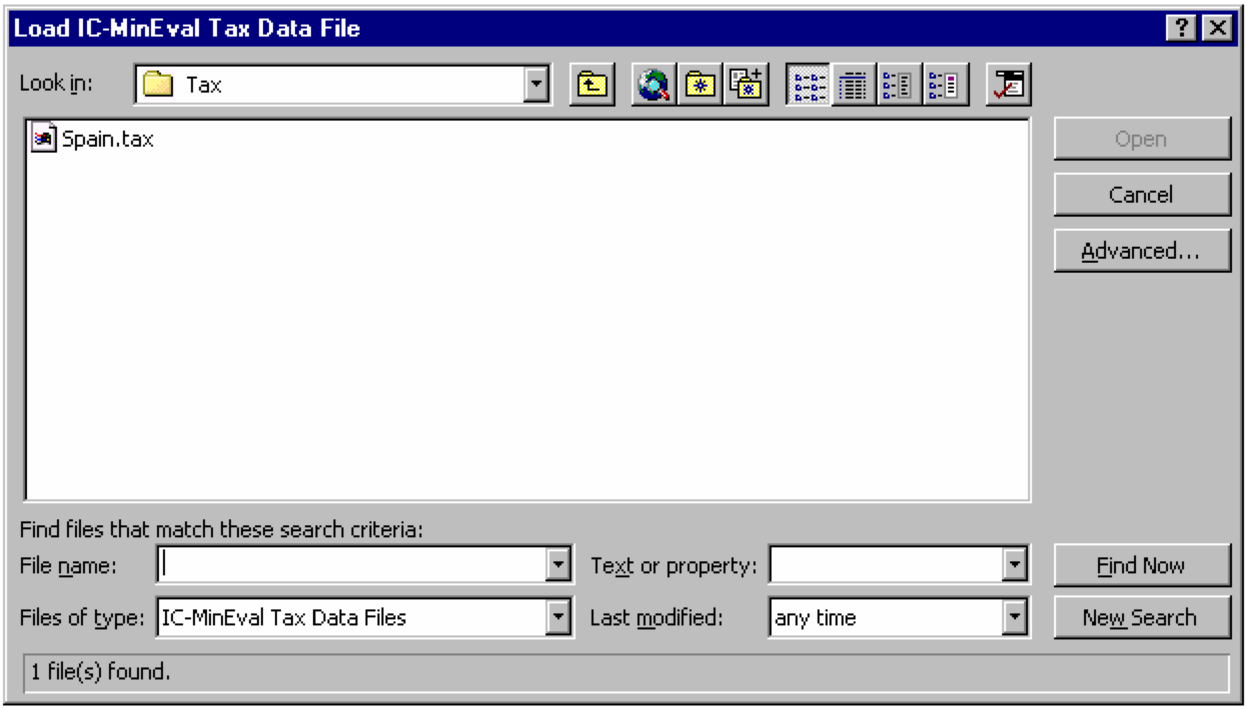

Figure 10.20: Load Dataset.

10.3.3.4 Save Tax

Once you have created custom tax formulae on the *wshtTax* worksheet you can save it as a *.tax* file. *Save Tax* from the *Files Menu* will produce a dialog box prompting the user for a file name. The default name will be the first 8 letters of the project name defined in the *General Information* menu. The file produced will have the extension .tax and will be an Excel workbook with *wshtTax* containing all customised tax calculations.

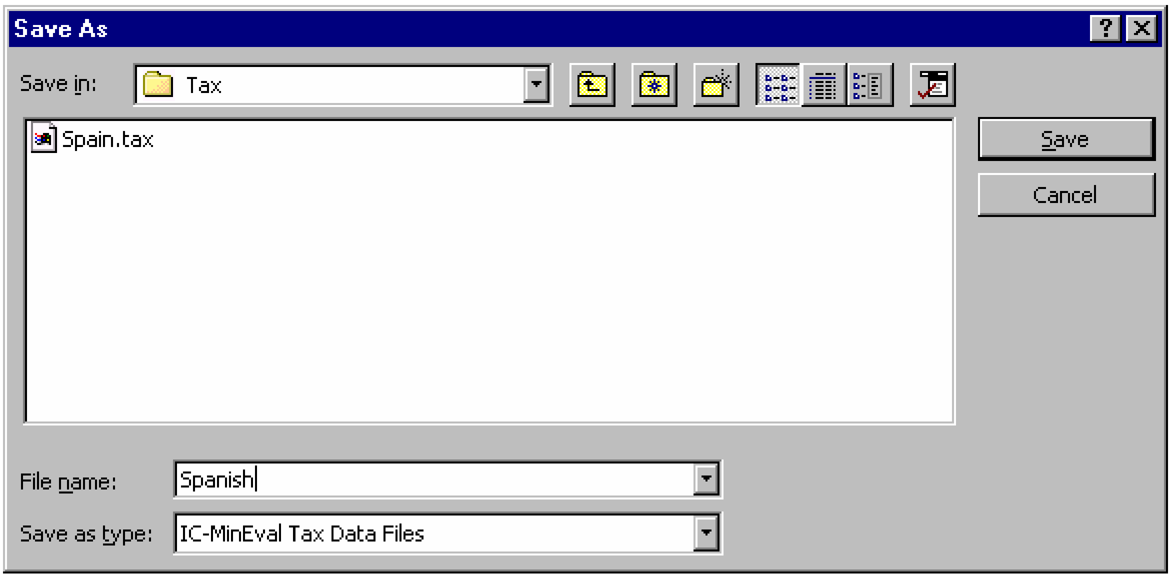

Figure 10.19: Save Tax.

10.3.5 Settings

The settings form allows the user to specify which worksheets and rows are updated by **IC-MinEval** each time it updates the model, excluding some of the worksheets or including their own custom sheets.

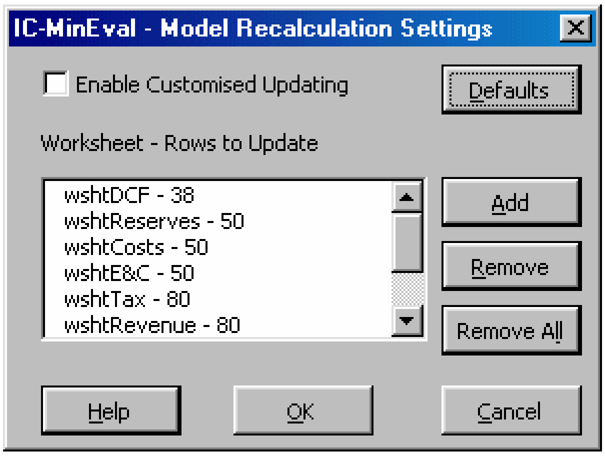

Figure 10.20: Settings.

Enable Customised Updating
Forces **IC-MinEval** to only update the worksheets specified in the list.
Defaults
Fills the list with the default worksheets and rows.
Add
Use the *add* button to include worksheets and specify which rows are automatically updated (figure 10.21). This works the same way as the sensitivity analysis selection, allowing the user to select a worksheet and then type in the number of rows to be updated.

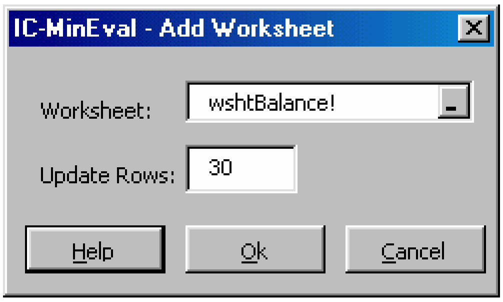

Figure 10.21: Add Worksheet

Remove
Highlight the worksheet you want to remove in the list of worksheets and then click remove to remove it.
Remove All
Removes all the worksheets from the list.

Note: Removing all the worksheets from the list and selecting *Enable Customised Updating* will result in none of the worksheets being updated, only the input data you entered in the forms.

If the user does not wish to update some of the data in the model from a form, each form now has an option allowing the user to exclude that input when entering data, e.g.

11. IC–MinEval Tutorial Exercise – Coal Project Finance

The following tutorial shows how quick and easy it is to create a full DCF model with sensitivity analysis using **IC-MinEval**. The session revisits and builds on the basic functions of **IC-MinEval** covered in *chapter 9* and introduces the *project finance* menu. At the end of the tutorial you will have created a full DCF model of a large-scale coal project with debt finance, and will learn how **IC-MinEval** can be used to automate the financial engineering and sensitivity analysis. The case history describes a large open pit coal project similar to those found in Western Australia.

Scenario

"It is proposed to establish an open pit coal mine with a capacity of 10,000 tonnes of mixed quality coal per day (in calculations 325 working days per year). The mining reserves are 39 million tonnes of in-situ coal (SG 1.3) with an estimated quality of 90% steam grade, 5% coking grade and 5% anthracite. It is estimated that the dilution will be 5% and the mining recovery will be 85%. The wash recovery for each coal product will be 90%.

Coal will be mined by truck-shovel methods with blasted overburden being stripped by a combination of power shovels and hydraulic excavators and hauled to disposal sites by dump trucks. The average striping ratio for the process is 6 tonnes of waste for each tonne of coal mined. The exposed coal seam will be cleaned by bulldozers and loaded into coal dump trucks by front-end loaders. Bulldozers will also be involved in on going surface land rehabilitation in mined-out areas. The mine will operate at 50% of its capacity in the initial production year and ramp up to 75% the following year. Full production capacity will be reached by the third year.

The capital cost is estimated to be US $42.54 million, based on the cost of purchasing the required mining equipment and developing the mine infrastructure (US $38.67 million), and capital overheads of 10%. There will be two pre-production years, with 60% of the total capital required in the first year and the remainder in the second. The unit operating costs of the mining operation are estimated at US $6 per tonne of coal mined and US $0.5 per tonne of waste mined. The milling costs are estimated to be US $2 per tonne, and any further processing costs are met by the customer. Working capital is budgeted at 25% of annual operating costs.

All coal is to be sold on contract to an adjacent power station who will carry out any further coal processing themselves. The cost of transporting the coal to the customer is negligible. For the purpose of modelling, average coal contract sale prices are assumed fixed at US $26 per tonne of steam coal, US $40 per tonne of coking coal, and US $35 per tonne of anthracite. Tax is set at 30% of taxable income and a royalty of 5% of gross coal value is payable. Capital allowances can be claimed as straight-line depreciation over the mine life. Environmental costs will amount to US $0.5 million per annum during mining and US $1 million in each of the two closure years to meet land rehabilitation requirements.

The project sponsors are seeking to finance 60% of the total capital requirement with debt and 40% with equity. The bank is willing to lend at an interest rate of 9.5% and require straight loan annual repayments over 5 years, with a 2-year grace period before repayment commences. The project discount rate is 10% and shareholders require a 15% return on equity. NPV will be calculated using the weighted average cost of capital. An up-front fee of 1% of the total debt is assumed with a 5% commitment fee. Fixed financing charges will amount to US $0.25 million and there is a contingency of 2% to act as a cushion against unexpected cost rises."

Exercise
Follow the instructions for opening **IC-MinEval** described in *chapter 8* in order to bring up the Main Menu. You can now set-up the DCF model by identifying the key project data from the scenario described above and entering it into the appropriate **IC-MinEval** data form. Try to decide yourself which data is required for each particular entry form. Screenshots of the correctly completed forms are shown below in case you encounter difficulties. Ignore the *Amount* tabs on the *Project Finance* form for the time being.

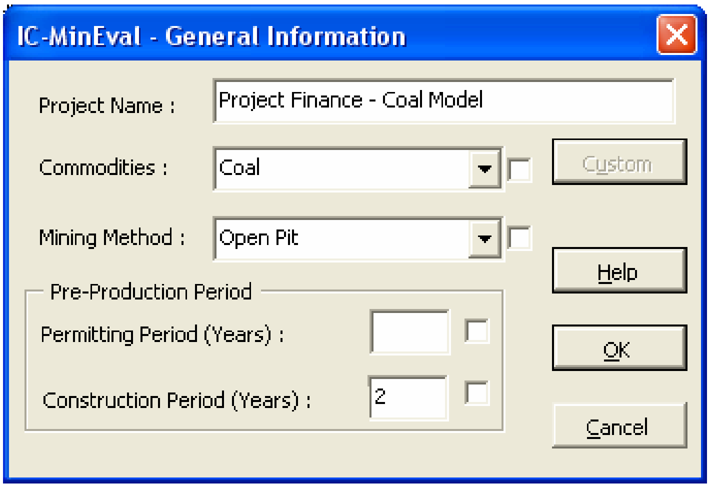

Figure 11.1: General Information

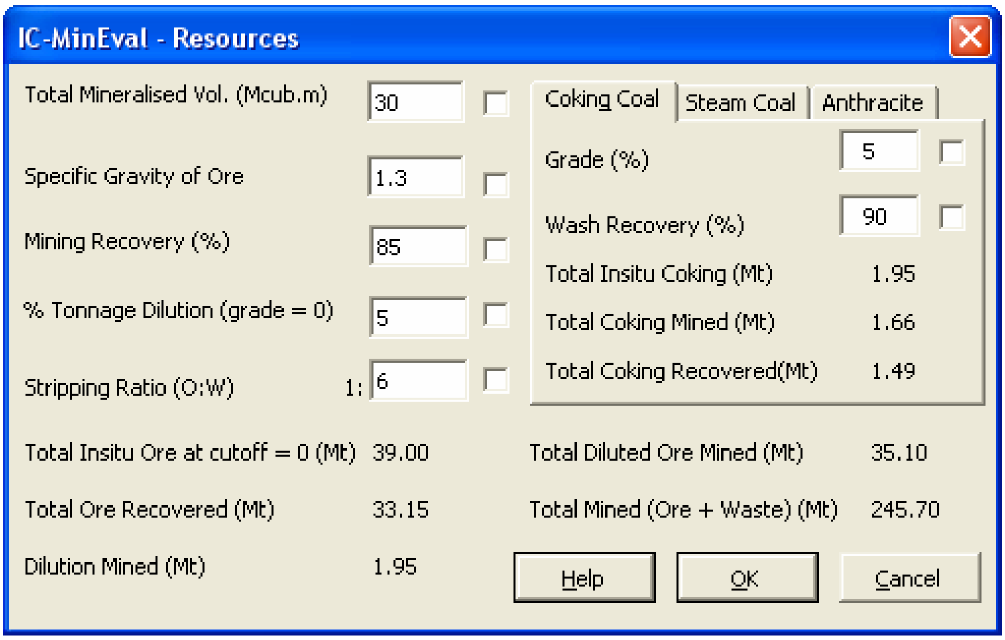

Figure 11.2: Resources

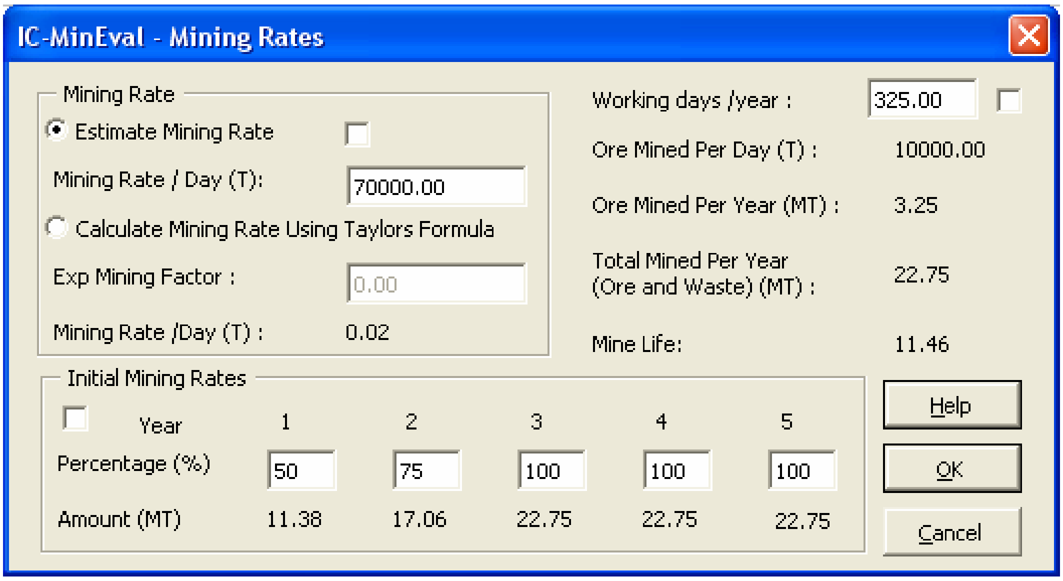

Figure 11.3: Mining Rates

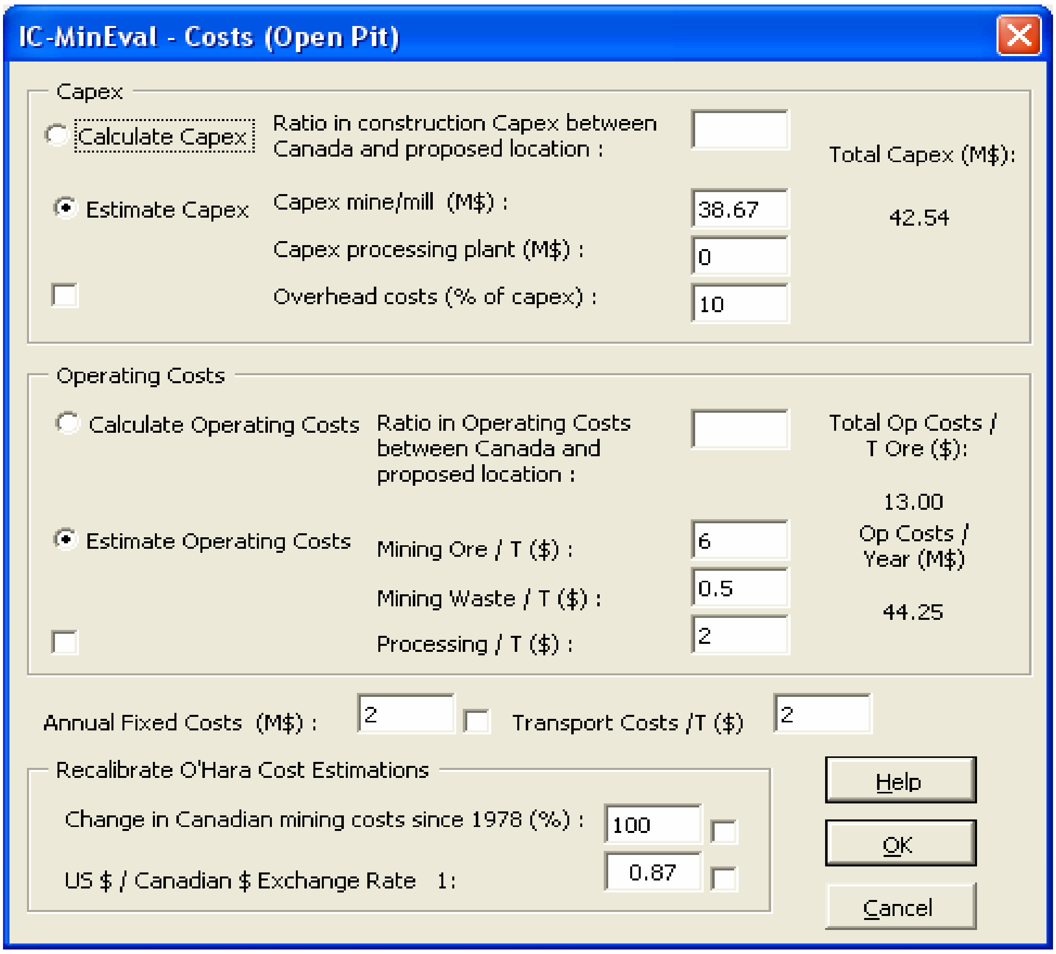

Figure 11.4: Costs

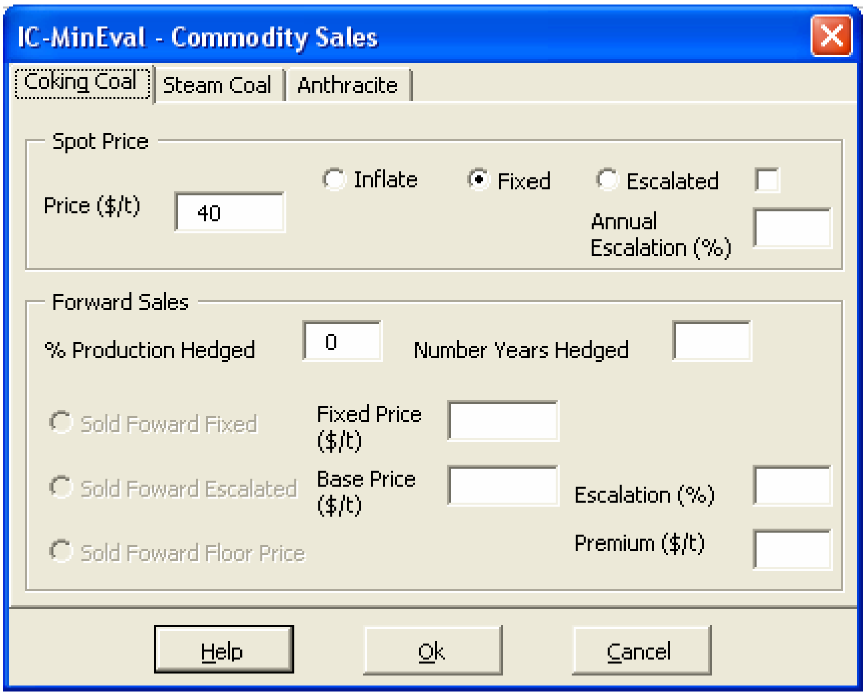

Figure 11.5: Commodity Sales

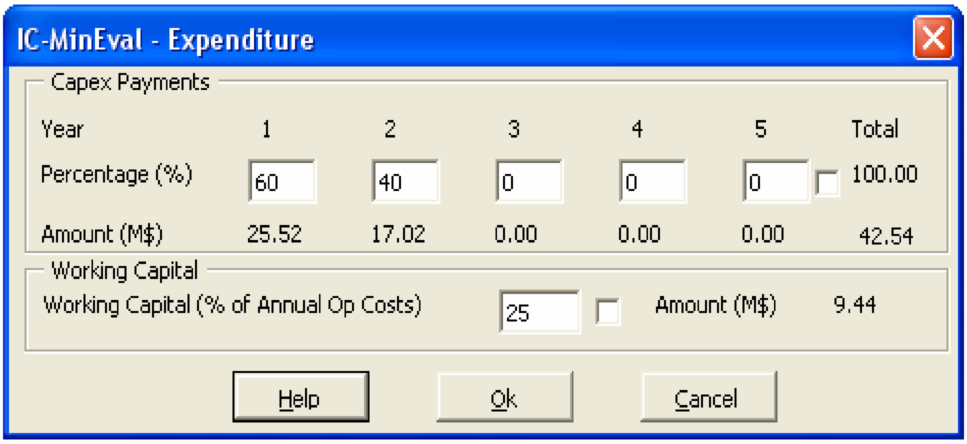

Figure 11.6: Expenditure

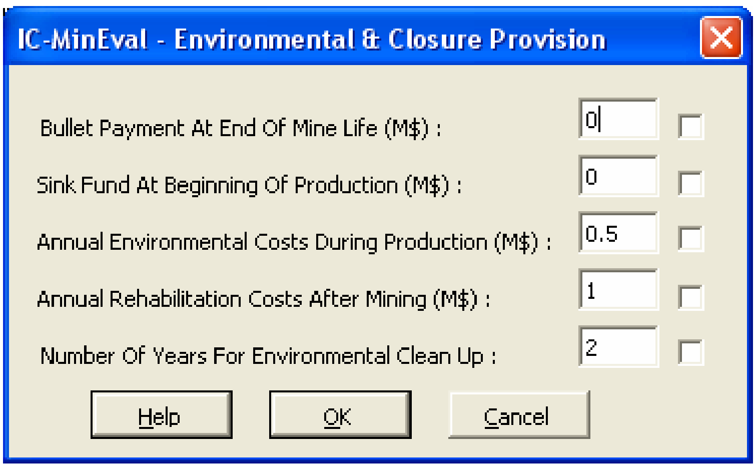

Figure 11.7: Environmental & Closure Provision

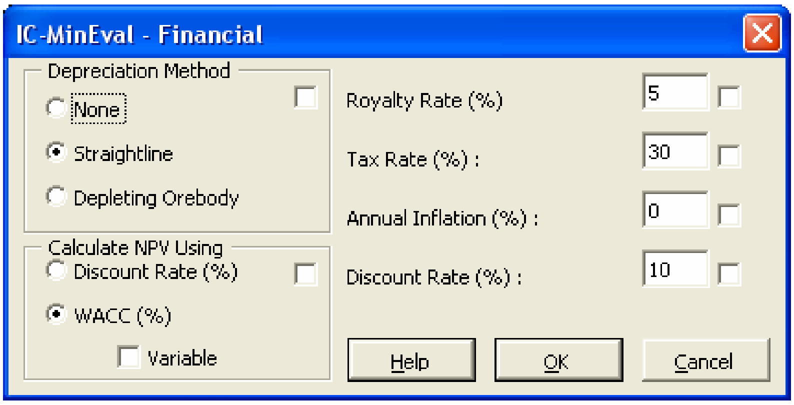

Figure 11.8: Financial

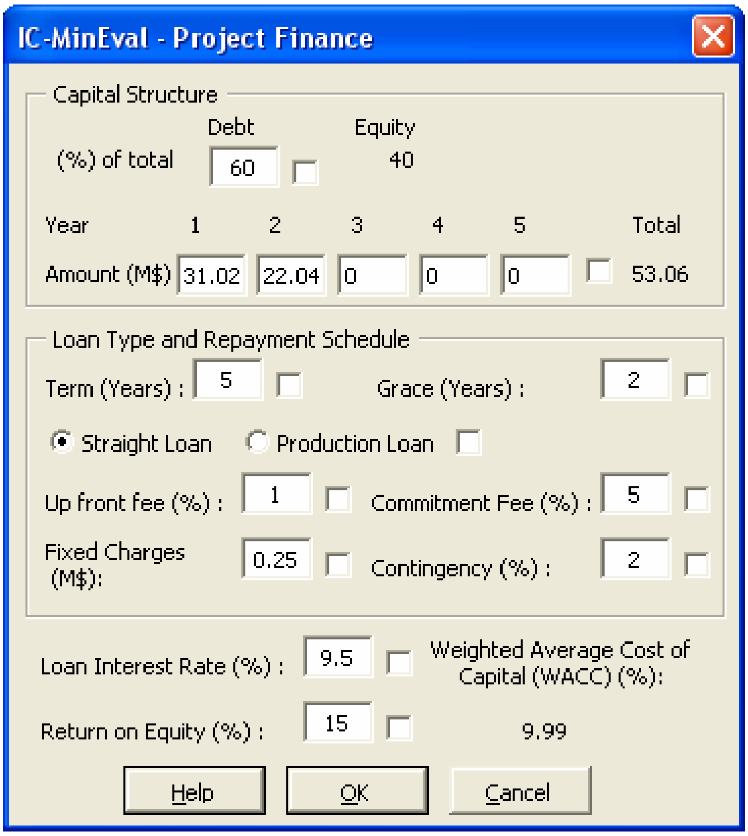

Figure 11.9: Project Finance

Results and Analysis

If you have correctly entered the data on each of the input forms on the main menu you will have created a fully linked financial model of the coal project. The DCF output sheet (*wshtDCF*) should yield the following results:

Pay Back Period (ATBI) (Years)	4.93
Max Cash Exposure (ATBI) (M$)	-47.04
NPV (ATBI) (M$) :	75.29
IRR (ATBI):	32.26%

These figures suggest that the case example project is financially viable. You can survey the projected *profit and loss accounts*, *balance sheets* and *cash flow charts* that **IC-MinEval** has automatically created to assess the project economics in more detail.

Funding

Although the key results of the discounted cash flow analysis are favourable, when looking at *wshtFinance* you will notice that the *cash balance after funding* is negative in the two pre-production years and the *cumulative cash flow* is negative until year 5. The major financial ratios are also below the recommended minimum levels in the early years of the project. This suggests that the level of debt and equity funding drawdown in the pre-production years needs to be adjusted. The financial engineering carried out by investment bankers in order to optimise this funding structure can be a lengthy and complex task. However, **IC-MinEval** can carry out all the financial engineering and automatically update the model for you in a matter of seconds.

Bring up the Main Menu by clicking on *IC-MinEval* on the toolbar at the top of the screen and selecting *Show Menu*. Click on the *Funding* button under the Analyse Model section of the menu. **IC-MinEval** will now spend a few seconds analysing the funding structure and re-calculating each line in *wshtFinance* at the revised optimum drawdown level. All the other output sheets in **IC-MinEval** will be automatically updated.

You should now find that the cash balance *after* funding is positive even in the pre-production years and that the major financial ratios in *wshtFinance* are more favourable. The funding drawdown structure can be adjusted manually on the funding *Amount* entry on the *Project Finance* form (see *figure 11.9*).

Sensitivity Analysis

Now try and run a quick sensitivity analysis to test the project's sensitivity to *Capex*, *Operating Costs* and *Mining Recovery*. Bring up the Main Menu and click on the *Sensitivity* button under the Analyse Model section. We want to analyse the project's NPV so make sure this is selected on the Sensitivity Analysis menu and keep the *flex* amount at the default settings. You can now select the variables to be flexed using the *Add* button as described in section *10.3.1*. Use the *Select Cell* feature to select the variables from *wshtInputData* that are to be analysed. You should select the total Capex figure (M$42.54), total Operating Costs figure ($11/t) and Mining Rate figure (85%) to analyse these variables.

When you have selected all the variables you want to analyse, click *OK* on the Sensitivity Analysis menu. A spider-graph displaying the project's sensitivity to changing Capex, Operating Costs and Mining Rate will automatically appear and should look like the chart shown in figure 11.10.

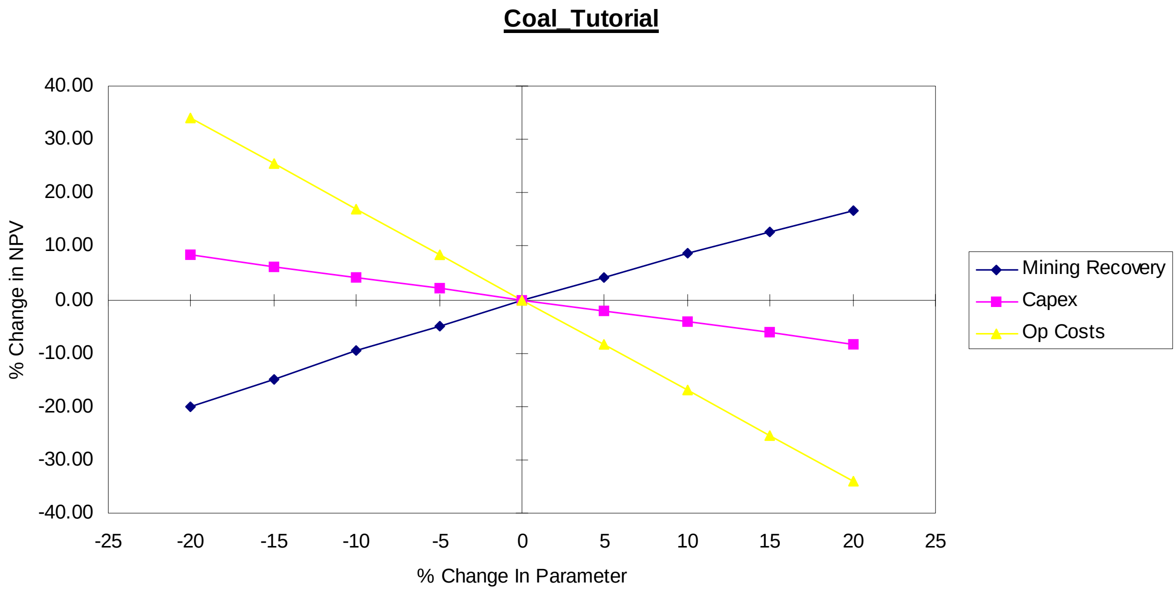

Figure 11.10: Coal Project Sensitivity Analysis

You have now learnt to use **IC-MinEval** to model an operation with project finance and have seen how the software can be used to carry out the financial engineering necessary too optimise the funding structure. Experiment with varying the input data on the *Project Finance* form to investigate the effect on the project economics of changing the finance structure. Practice using the *Analyse Model* functions on the Main Menu – these are powerful evaluative tools and let you quickly carry out downstream-level analysis on your project even if it is only at a very early stage of development.

12. Un-Installing IC-MinEval

IC-MinEval creates an uninstall file during installation to simplify removal should you wish to upgrade to a newer version or remove **IC-MinEval** completely. To un-install **IC-MinEval**:

1. Double click on the "*My Computer*" icon on your desktop.
2. Double click on the "*Control Panel*" icon.
3. Double click on the "*Add/ Remove Programs*" icon.
4. Select "IC-MinEval" from the list.
5. Click on "*Add/Remove*" and follow the on screen prompts.

IC-MinEval will now have been completely removed from your system.

If you created a desktop shortcut to IC-MinEval as described in section *4. Installing IC-MinEval*.

1. Click on the shortcut icon once (if you double click, it will attempt to run **IC-MinEval**).
2. Press *delete* (normally marked *Del*) on your keyboard and select *Yes* to remove the shortcut.

Appendix A – Producing Custom Tax Models

Due to the complexities of international mining taxation it is impossible to produce a model that will be applicable in all situations. As a result we have tried to simplify the process of producing a customised tax model in **IC-MinEval**.

Using the *load* and *save* Tax Model in the *Files* module it is possible to create a series of Tax Models for different taxation regimes that you can load into **IC-MinEval**. As a quick guide to customising the Tax Models a sample tax model "*Tax1.tax*" is included in the samples directory of **IC-MinEval** and the changes made are discussed as follows.

IC-MinEval uses "*names*" to refer to ranges of cells in Excel making it easier to modify the models as only these "*names*" and not the actual cell references are used in most cases.

Changing Tax Formula

Only the Tax Paid (named "*Tax*") and Tax Payable (named "*TaxAfterFunding*") are take through to the DCF and P&L accounts.

In the example there is a simple loss carried forward calculation where the taxable income is equal to the current years profits (*PBIT* or *PAIBT* as appropriate) + the previous years losses (with losses carried forward indefinitely).

As you can see all the changes for depreciation and tax are only carried out on *wshtTax* making the tax models self-contained and independent of the rest of the model.

Depreciating Capex

Any changes to depreciation should be only done on *wshtTax*. The sample tax sheet shows how this can be achieved and allows Capex payments spread over up to 12 years (can be less) to be depreciated over X years. By changing cell C3 you can vary the write off period. Changing this to 1 lets you write off all Capex payments (in that year) immediately. Obviously, if you haven't made a Capex payment yet, you can't write it off.

The formula for depreciation may look complex, but it is in essence quite simple. The main part is:

+IF(AND(CurrentYear>1,CurrentYear<=$C$3+1),$D$4/$C$3,0)

The first part *(AND(CurrentYear>1,CurrentYear<=$C$3+1)* checks year 2 Capex and checks whether it has been paid yet *(CurrentYear>1)* and whether there is any left to be written off *(CurrentYear<=$C$3+1)* where *$C$3* is the depreciation period. If there is Capex to be depreciated *$D$4/$C$3* does it, otherwise it is 0.

As Capex payments this formula is repeated to cover extra years. You can write off up to 12 years of Capex payments, but if you wish to make Capex payments over a greater period you can add extra formula after *+IF(AND(CurrentYear>7,CurrentYear<=$C$3+10),$M$4/$C$3,0)*

Increasing the 7 and the $M$4 e.g.

+IF(AND(CurrentYear>8,CurrentYear<=$C$3+10),$N$4/$C$3,0)

+IF(AND(CurrentYear>9,CurrentYear<=$C$3+10),$O$4/$C$3,0)

This is automatically linked to the P&L account and so you should now only have one taxable income.

Please note:

If you have a very long depreciation period and / or Capex spread you will need to check that all the Capex is depreciated before the end of the project life (you can check the total Capex = total Depreciation), otherwise you will need to add extra years. This can be done by increasing the rehab period in the environmental sheet to cover the necessary period. However, this would not be very realistic in real terms as you would want all your Capex depreciated whilst you had revenue to write it off against.

Appendix B – Financial Ratios

IC-MinEval calculates a series of financial ratios in wshtFinance whose analysis is the primary cash flow tools in project finance. These can be split into:

- Annual cover ratios
- PV cover ratios
- Overall ratios

Annual Cover Ratios

The Annual Cover Ratios are:

- Interest
  Available Cash Flow / Interest Rate
- Principal :
  Available Cash Flow / Principal or
  (available Cash Flow - Interest Rate)/ Principal
- Debt Service Cover Ratio:
  (Available Cash Flow - Debt Service) / Debt Service

PV Cover Ratios

The Present Value (*PV*) cover ratios are:

- Loan Life Ratio (*LLR*)
  NPV of cash flows after funding during loan period, discounted by the interest rate.
- Project Life Ratio (*PLR*)
  NPV of cash flows after funding during entire project, discounted by the interest rate.

The difference between *LLR* and *PLR* is a measure of the residual cash flow cover.

Overall Ratios

Other ratios that are used are:

- Debt: Equity Ratio
  Projects with high market risk, typically 50:50 or 60:40, those with lower risk 75:25
- Residual Cover
  PV of post loan maturity cash flows / maximum loan.

Appendix C – Commodity Groups and Host Deposit Types

Metal Group	Host Deposit Type	Deposit Example	General Characteristics
Au	Shear-hosted	Fimiston, Sunrise Dam - WA, Ashanti - Ghana, Witwatersrand – SA	Archaean age mesothermal lode deposits located in crustal scale shear zones (accreted terranes associated with Archaean convergent plate margins). Large vertical extent with subtle vertical zonation and strong structural controls on mineralisation.
	Palaeo-conglomerates	Alluvial (Magaden – Russia	Gold-bearing conglomerates formed by weathering of Archaean greenstone belts. Occur in basin-controlled reefs. Average grade is around 7g/t Au.
Cu	Carbonatite	Palabora - SA	Proterozoic to recent intrusive magmatic carbonates and associated alkaline igneous rocks, found in the marginal parts of stable cratonic regions with major rift faulting.
Ag	Epithermal silver		Economic deposits of silver formed by hydrothermal fluids at shallow depth (near surface to 1500 m). Associated with extrusive or near-surface intrusive igneous rocks.
Pb,Zn,Ag	Carbonate-hosted	Galmoy - Ireland, Reocin - Spain, Pine Point - Canada	Phanerozoic base metal deposits of variable type found in thick sequences of dolomite or limestone rocks. Formed in warm seas in cratonic basin-shelf environments. Average grade is 3-10% (combined). Variable tonnage.
Cu,Mo	Porphyry	La Escondida – Chile	Low grade (0.5-2% copper), large tonnage (up to 1000 Mt) deposits associated with calc-alkaline intrusive suites in continental margins (cordillera) and island arcs. Most are younger than 200 Ma and are hosted in or adjacent to narrow porphyritic stocks associated with large batholiths. Molybdenum may also occur in economic quantities
Cu,Au	Skarn	Nickel Plate – Canada, La Luz - Nicaragua	Phanerozoic deposits formed by the replacement of pre-existing rocks at high temperatures at contact with medium to large sized igneous intrusions. Found in orogenic belts at convergent plate margins, and are usually associated with syn to late intracratonic island arc intrusions emplaced into calcareous sequences in arc or back-arc environments. Average grade is around 4.5g/t gold.
	Porphyry	Grasberg – Indonesia, Bingham – USA	See *Cu,Mo porphyries.*
Cu,Zn	Volcanogenic	Neves Corvo - Portugal, Black Mountain - SA	Stratiform massive sulphide deposits developed at the interfaces between two volcanic units or a volcanic and sedimentary unit. Form at active constructive or destructive plate margins and

			usually underlain by a hydrothermal stockwork.
Cu,Zn,Sn	Granite-hosted tin	South Crofty – UK	Stockwork deposits hosted in granitic plutons, often of a porphyritic texture. These deposits have much in common with porphyry coppers and are associated with ancient convergent plate margins. Generally low grade.
Au,Cu,Ag	Hydrothermal	Muruntau - Uzbekistan	Sediment hosted precious metal deposits. Diagenesis of source rocks re-mobolises and concentrates metals in hydrothermal fluids.
Cu,Ag	Kupferschiefer	Lublin – Poland	Stratiform sulphide deposits of sedimentary affiliation that occur in non-volcanic marine or deltaic environments. The host sediments are frequently organic-rich and there is often more than one ore layer present. Proterozoic to Tertiary in age. Highly variable tonnages.
Au,Ag	Epithermal gold	Carlin – USA, McLaughlin – USA, Lepanto - Philippines	Gold deposits formed at shallow depth (near surface to 1500 m) in active convergent plate tectonic settings. Associated with felsic to calc-alkaline volcanic suites and are divided into low sulphidation types (vein mineralisation) and high sulphidation types (disseminated mineralisation). May also yield economic concentrations of silver as a by-product.
Cu,Ni	Mafic magmatic sulphide-hosted	Mt Keith - WA, Voisey Bay – Canada	Primary sulphide deposits hosted in ultramafic igneous rocks in Archaean greenstone terranes. Nickel grades are typically 1-5% and tonnages are moderate to high. Copper may be present as an economic by-product.
Diamonds	Kimberlite	Premier – SA	Diamonds associated with volatile-rich ultramafic igneous rocks occurring in volcanic pipes, dykes and sills. Kimberlites first appear in the Proterozoic and are found in continental cratons. Their location appears to be controlled by deep-seated fracture systems. Diamonds are sparsely concentrated throughout the kimberlite host rocks.
	Alluvial and marine	Kleinsee – SA	Clastic sediment hosted diamonds in alluvial or shallow marine basin settings. Weathering releases diamonds from their source kimberlite rocks and gravity separation by flowing water concentrates them into economic placer deposits. Usually include gem quality stones but concentration is highly variable.
Pt,Pd,Rh,Ir,Ru,Os	Layered mafic intrusions	Bushveld UG2 – SA	Orthomagmatic sulphide deposits formed in large, stratiform, layered igneous complexes in Proterozoic cratonic settings. Their origin is intimately associated with the high temperature processes of magma formation and crystallisation. High tonnage, platinum group element ore bodies.
Pt,Pd,Rh,Ir,Ru,Os, Cu,Ni	Layered mafic	Bushveld Merensky	Same geological setting and genesis as

	intrusions	Reef - SA, Stillwater – USA	described above. Differences in the stage of geochemical evolution of the source magma results in the economic concentration of nickel and copper within certain layers, in addition to accessory platinum group elements.
Pt,Pd,Rh,Au	Alluvial	Goodnews Bay – USA	Clastic sediment hosted placer deposits found in alluvial basins. Formed by the weathering of mafic igneous complexes (see above) and the subsequent concentration and deposition of the freed platinum group elements and gold by fluvial processes.
Pt,Pd,Rh,Ir,Ru,Au, Cu,Ni	Layered mafic intrusions	Bushveld Merensky Reef - SA, Norilisk - Russia, Sudbury – Canada	Same geological setting and genesis as described earlier. Differences in the stage of geochemical evolution of the source magma results in the economic concentration of nickel, copper and gold within certain layers, in addition to accessory platinum group elements.
Coal	Open Pit	Witbank - SA, Griffin – WA	Shallow lying stratiform coal seams amenable to surface mining techniques. Overburden usually consists of a relatively thin sequence of mid to late Phanerozoic sediments. Coal may be classified as coking, steam or anthracite depending on the level of coalificaton attained and its physical and chemical properties.
Ind Min (industrial minerals)	Laterite (Ni)	Murrin Murrin – WA	Laterally extensive surficial deposits, often the result of secondary mineralisation in soil profiles due to the weathering of crystalline parent rocks in tropical climates. Such commodities are usually bulk, high volume, low value mine products.
	Bauxite (Al)	Huntly –WA	
	Stratabound Iron	Thabazimbi - SA, Hamersley – WA	
	Stratabound Mn	Sichen – SA	
	Chromitite	Dwars River –SA	Chromium is won from the mineral chromitite, which occurs in stratiform and podiform deposit types. Stratiform chromitites are associated with ultrabasic layered igneous complexes. Podiform deposits show a different structural form and are associated with tectonised ultrabasic sequences of ophiolite complexes.
	Tantalite	Greenbushes – WA	Tantalum is won from tantalite, a mineral often associated with sheared Archaean granite-greenstone terranes. Tantalite is a low volume, high value mine product.